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PROF. PASTEUR'S LABORATORY FOR THE STUDY OF RABIES.

THE remarkable communications that Mr. Pasteur has recently made to the Academy of Sciences upon the subject of his new study of rabies have again attracted the attention of scientists and the public to the discoveries of this illustrious chemist. The laboratory of the Normal School, wherein so many great labors have already been performed, is at present being conducted in a very uncommon manner, and Mr. Pasteur, thanks to the liberality of the Municipal Council of Paris, has been enabled to construct kennels for mad dogs, coops for poultry afflicted with chicken cholera, pens for measly swine, and stables and sheepfolds for animals suffering from the disease known as charbon.

Mr. Pasteur's laboratory consists of a vast building which comprises only a ground floor and basement. In the former are found several large halls designed for analyses and microscopic observations, and a weighing room and workrooms. The large store room that Mr. Pasteur has had constructed for cultivating at definite temperatures the microbes and viruses that he is studying is a small rectangular apartment which is entered through a double door that permits of a very constant temperature being maintained within. The desired degree of temperature is obtained through a stove whose piping is properly arranged against the walls of the room (Fig. 1). All around the room there are arranged shelves upon which are placed the culture bottles. These latter usually consist of small matrasses whose neck is closed by a long ground glass stopper formed of a hollow tube containing a wad of cotton. The object of the latter is to allow only filtered air, deprived of the dust and germs that it holds in suspension, to enter the experimental liquid. Here cultures are made of virulent microbes that would suffice to kill entire armies. These microscopic beings, sown in a liquid favorable to their development, multiply with wonderful rapidity.

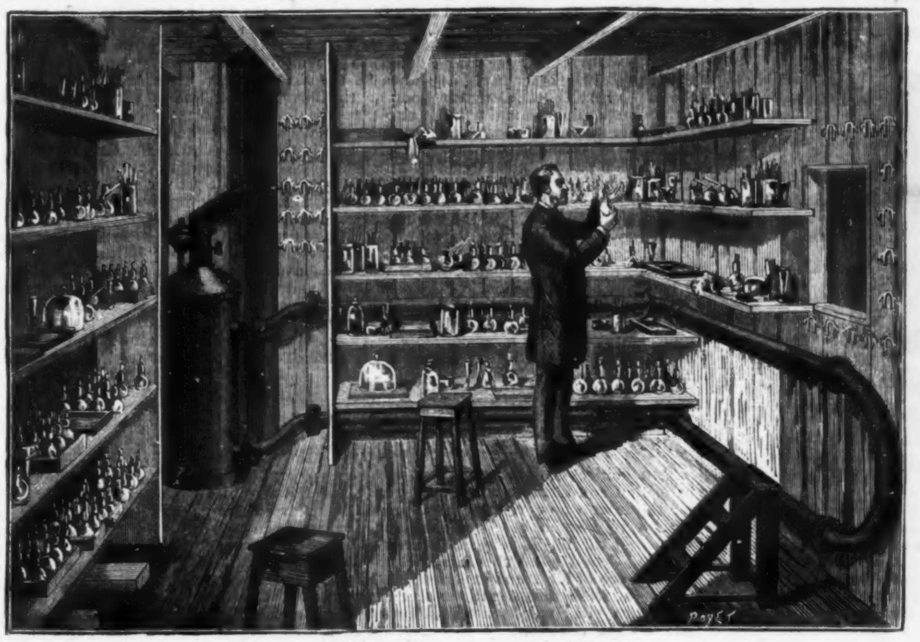


FIG. 1.—MR. PASTEUR'S STORE ROOM.

The basement of the laboratory on Ulm Street now contains a host of beasts under experiment. Here, in a large, oblong apartment, is seen a series of cages containing rabbits into whose brain has been inserted a bit of the brain of an animal that has died of rabies. Labels, to which additions are daily made, give a *resume* of the progress of the experiment. The beasts go and come in their cages, and here and there some are seen lying upon their side, paralyzed and immovable, and about to die. In another room hens are seen sticking their heads out through the bars of their cages. Further on there are monkeys and Guinea pigs destined for inoculation.

FIG. 2.—CAGE FOR ISOLATING A MAD DOG.

One special hall is devoted to mad dogs. These animals are confined separately in round cages that can be opened at the top and side. These openings are designed for the introduction of food to the dog, or to allow of his being seized by means of a noose when he is needed for an experiment (Fig. 2). Some of the animals are afflicted with violent madness and bark frightfully. Others carry the germ of the terrible malady, but are still gentle, and inspire one with genuine pity. They have a sad, dejected look, and beseech a regard from the visitor.

Mr. Pasteur's laboratory possesses, in addition, vast dependencies situated in the neighborhood, in the center of the garden of the old Rollin College. Here are located the stables, hog pens, henhouses, and sheepfolds, all filled with animals for study.

The kennel designed for mad animals is built in one of the corners of the inclosure. Each dog is confined in a double cage, from one of whose compartments he may be made to enter the other, so that he may be fed and the place be cleaned up where he passed the night. There is a passageway all around the kennel, as shown in Fig. 3, which was drawn from nature.

"Never," says Mr. Pasteur in one of his lectures, when he had just killed a bird in air deprived of oxygen, "should I have the courage to kill a bird by shooting it; but, when it concerns experiments, I am deterred by no scruples. Science has the right to invoke the sovereignty of the end in view."

Such are, succinctly described, the facilities that Mr. Pasteur has now at his disposal for the accomplishment of his labors. Immense discoveries have already issued from this laboratory, and others are still to be made there. Mr. Pasteur and his fellow-workers, Messrs. Chamberland and Roux, are now deeply immersed in the study of rabies, and the results that they have already obtained are of a nature to make it hoped that the day is not far distant when they will find a means of preventing this terrible malady.

In a book entitled "Mr. Pasteur, the History of a Scientist by an Ignorant Man," we read the following: "Dogs, biting and bitten, fill the laboratory. Without counting the hundreds of dogs which, during the last three years, have died mad at the laboratory, there does not occur a single case of rabies at Paris that Mr. Pasteur is not notified of. 'Poodle and bulldog violently attacked,' telegraphed a veterinary surgeon to him not long since; 'come.'"

"Mr. Pasteur," says the author of the book referred to, "proposed that I should accompany him, and we started, carrying six rabbits in a basket. The two dogs were rabid to the last degree. The bulldog especially, an enormous animal, was howling and foaming in his cage. When a bar of iron was held toward him he rushed at it, and it was with difficulty that it could be wrested from his blood-covered fangs. Then one of the rabbits was held near the cage, and the drooping ear of the frightened animal was stuck through the bars. But, despite all excitation, the dog betook himself to the back of the cage and refused to bite. 'We must, nevertheless,' said Mr. Pasteur, 'inoculate the rabbit with his slaver.'

"Two boys took a cord provided with a slip noose and threw it at the dog as one would throw a lasso, and he was thus caught and led to the edge of the cage. He was then seized, his jaw was tied, and choking with rage and with eyes injected with blood, and his body shaking with a furious spasm, he was laid upon the table and held immovable while Mr. Pasteur, leaning over the foaming head, sucked up through a tapering tube a few drops of the slaver. It was in this veterinary surgeon's cellar, and in sight of that formidable head, that Mr. Pasteur appeared to me the greatest."

Upon leaving Mr. Pasteur's laboratory, we walked along with a friend, who recalled to us the severe sickness that the great chemist experienced a few years ago. Mr. Pasteur, said he to me, although bedridden, still continued to dictate to his wife the notes that he was to communicate to the Academy of Sciences in regard to the studies that he had so much at heart. He continued verifying and watching the laboratory experiments, whose results were communicated to him by his assistants, and, believing at that time that his life was about at an end, he said to Henri Sainte Claire Deville, who had hastened to his bedside, "I regret to die; I should have desired to render more services to my country."

A soul so much the mistress of the body ended by triumphing over disease. But, having been paralyzed on the left side, Mr. Pasteur never regained the entire use of his limbs, and to-day, sixteen years after this attack, he has the gait of a person who has been wounded.

But what triumphs were in store for this wounded man! In fact, Mr. Pasteur, who began his career with his fine studies upon molecular dissymmetry, with his capital discoveries regarding the nature of ferments, with his great labors on acetic fermentation and on spontaneous generation, and who conquered the silkworm disease and saved from ruin one of our most important national industries, kept moving from triumph to triumph in that domain of virulent diseases so obscure, so little known, and so difficult to investigate, and proceeded to find the cause of charbon and chicken cholera and to discover the vaccine of this virus, that is to say, to place the remedy alongside of the disease. Such discoveries,

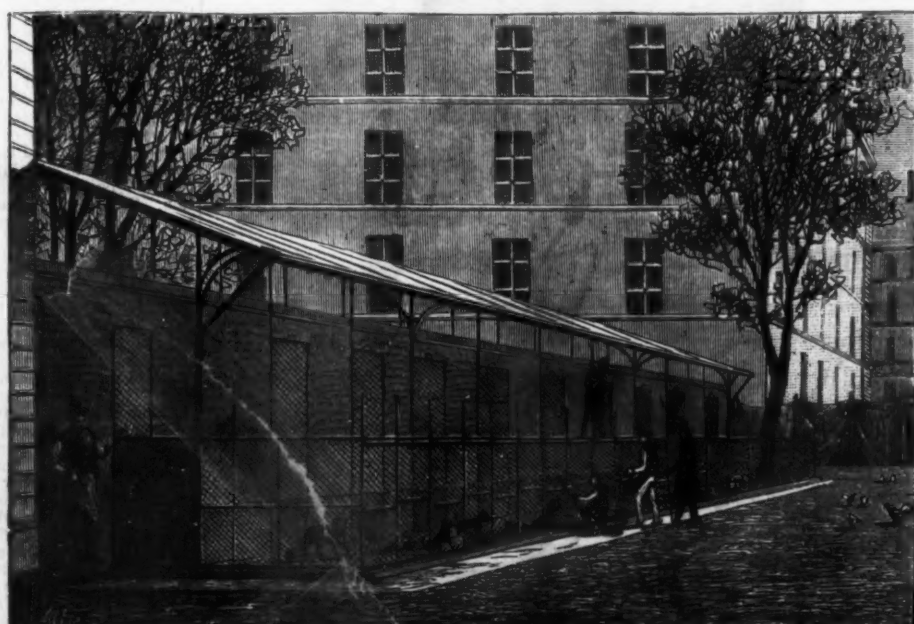


FIG. 3.—KENNEL FOR MAD DOGS.

PROF. PASTEUR'S LABORATORY FOR THE STUDY OF RABIES.

and many others yet the enumeration alone of which would exceed the limits of this notice, are opening up new horizons to science, and have justly attracted the admiration of the entire world to the author of them.

It was in 1880 that Mr. Pasteur began his new studies upon rabies. Aside from the attraction of an obscure problem, he felt that if he succeeded in discovering the etiology (possibly microbian) of such a malady he would convince every mind of the truth of his new theories. At the time of his first researches, Mr. Pasteur, after succeeding in transmitting rabies to a rabbit by means of the saliva of a child that had died of this terrible disease at the Trousseau Hospital, observed that the tissues and blood of this animal contained, in fact, a special microbe that was easily cultivatable in a state of purity, and the successive cultures of which caused other rabbits to perish.

Other and more important facts were soon to be shown. Mr. Pasteur and his colaborers were to recognize for the first time that the seat of rabies lies essentially in the brain. If a dog be trepanned and there be placed upon his brain a particle of the animal that has died of rabies, he will soon give the first signs of the rabid voice, and after rage and hallucinations, will die in the convulsions characteristic of the disease. Besides this, it was soon established that not only is the brain rabid, but that the entire length of the spinal marrow may be so likewise, and that the nerves themselves, throughout their length from center to periphery, may contain the virus of rabies. If the salivary glands are rabid, this is due to the fact that the nerves that end there gradually empty the virus therein.

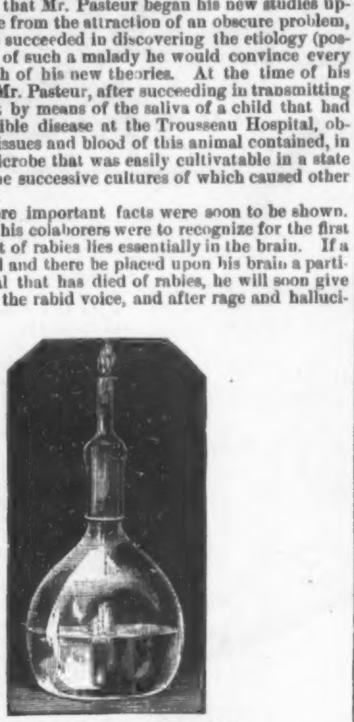


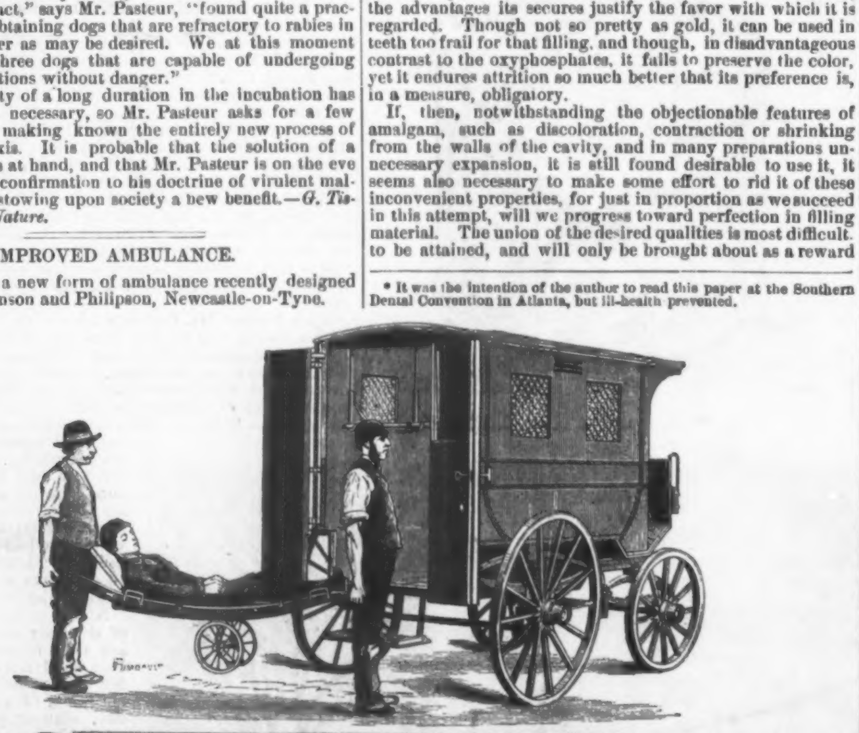
FIG. 4.—A CULTURE BOTTLE.

In his last communication to the Academy, Mr. Pasteur announced that he had already reached a great practical result. His colaborers and he had found that there existed dogs which were refractory to rabies with all modes of inoculation and with all kinds of rabid virus. Well, these animals were not refractory through their natural constitution. "We have, in fact," says Mr. Pasteur, "found quite a practical means of obtaining dogs that are refractory to rabies in as large a number as may be desired. We at this moment possess twenty-three dogs that are capable of undergoing virulent inoculations without danger."

The possibility of a long duration in the incubation has made prudence necessary, so Mr. Pasteur asks for a few months before making known the entirely new process of rabid prophylaxis. It is probable that the solution of a great problem is at hand, and that Mr. Pasteur is on the eve of giving a new confirmation to his doctrine of virulent maladies, and of bestowing upon society a new benefit.—*G. Tissandier, in La Nature.*

IMPROVED AMBULANCE.

WE illustrate a new form of ambulance recently designed by Messrs. Atkinson and Philipson, Newcastle-on-Tyne.



IMPROVED AMBULANCE.

Fig. 1 is a general view of the ambulance, and it will be perceived that although the wheels are high, producing easy draught, the body is hung very low to facilitate the entry of the stretcher, on which the patient is placed, by the door at the back of the vehicle. The axles are fitted with India-rubber collars, which prevent noise, and check the jar and strain of the wheels and undercarriage being transferred to the body. The springs are very elastic, but strong. The step at the back is long and broad, and the doors open outward. The fore part of the body is planned to allow the front wheels to lock or turn without hinderance in narrow thoroughfares. The driver is protected by a canopy, and at his side there is sitting accommodation for another person. In the floor of the ambulance a grooved track is provided, to admit and hold the wheels of the stretcher or couch, shown in Fig. 2. This was designed for carrying helpless persons expeditiously and comfortably in a variety of ways. The couch is framed in ash, with a pair of handles at each end. These as well as the feet are jointed so that they may be folded when the width of a staircase or passage will not allow the stretcher to be turned in its full length. On the frame, a spring mattress is stretched, and at the top an air pillow is provided; a pair of light wheels with India-rubber tires are added, but these can be detached at will, together with some of the other parts, as shown in the sketch; thus the couch may be run along the floor of the hospital with some degree of speed and without unpleasant motion.

Another stretcher is suspended over the couch when the latter is deposited in the ambulance. This is the canvas stretcher on parallel poles (see Fig. 2). These poles may be slipped out of the stretcher when the invalid is placed upon a bed, without disturbing him—a great advantage when a man cannot bear handling. In the van this stretcher is hung on rubber-covered hooks from the roof, and is kept firmly in its place by cross pieces. At the sides of the stretchers there are seats for three attendants, which with the invalids, the driver, and his companion, make seven in all, and with this load it is found that one horse works the ambulance with the greatest ease. Ample provision is made for ventilation and lighting, the latter by means of embossed glass windows during the daytime and by two ingeniously contrived lamps at night.—*Engineering.*

A NEW DENTAL AMALGAM.*

By A. H. BEST, M.D., L.D.S.R.C.S., Savannah, Ga.

THE subject of dental amalgam is worn so nearly threadbare, that considerable moral courage is absolutely requisite for those who now venture to approach it. Nevertheless, though very much has been said, and, perhaps, even more written on this fertile subject, it is not to be hastily assumed that the dental mind should abandon it as exhausted. An interchange of ideas and experiences stimulates thought and leads to fresh investigations and experiments. These in their turn yield results not in all cases wholly satisfactory, but always contributory to our stock of knowledge, and tending to still further elevate the scientific character of dentistry.

Amalgam, in the usual form, is now employed daily by thousands of operators. It undoubtedly saves many teeth that would otherwise be irretrievably lost; and although its use is as yet attended with results more or less uncertain, the advantages its secures justify the favor with which it is regarded. Though not so pretty as gold, it can be used in teeth too frail for that filling, and though, in disadvantageous contrast to the oxyphosphates, it fails to preserve the color, yet it endures attrition so much better that its preference is, in a measure, obligatory.

If, then, notwithstanding the objectionable features of amalgam, such as discoloration, contraction or shrinking from the walls of the cavity, and in many preparations unnecessary expansion, it is still found desirable to use it, it seems also necessary to make some effort to rid it of these inconvenient properties, for just in proportion as we succeed in this attempt, will we progress toward perfection in filling material. The union of the desired qualities is most difficult to be attained, and will only be brought about as a reward of unceasing investigation and experiment, and of untiring study of metallurgy in all its bearings on this special form of alloys. It has, indeed, been found so very difficult to accomplish this result in alloys made by the usual processes that, notwithstanding the number of experiments that have been made with varying compositions and under the most varied circumstances, the results are still far from satisfactory, and we may reasonably doubt the possibility of solving this important problem by the methods and upon the principles hitherto usually employed.

Nearly all dental amalgam alloys are composed principally of silver and tin, to which in many cases just enough of the more precious metals has been added to render the process of alloying more difficult and more destructive to the tin, and to justify the venders in giving their compound a name which it is hoped will help its sale. In this connection I may mention a simple fact in my experience, which probably has its parallel in that of many other operators. For many years I used nothing but the most costly alloys, yet to my great regret the results obtained from them were anything but satisfactory, and in many cases decidedly inferior to those attending the use of cheaper grades of alloys, for which no claim of containing gold or platinum was urged as a recommendation. It would, in fact, seem that the degrees of heat necessary for the complete fusion of those metals differ so greatly—the fusing point of platinum being so very high and that of tin so low—that alloys containing platinum or gold are really and practically so much injured thereby that in many cases the propriety of such addition is questionable. Even in using but two metals, silver and tin, whose various combinations are supposed to represent the cheaper grades of amalgam alloys, the greatest possible care has not completely overcome that obstacle which so greatly affects the qualities of such alloys, viz., the "burning of the tin" (as it is familiarly styled) by contact with the molten silver. Neither is this a matter of surprise when the melting points of the two metals, and their behavior under such conditions, are taken into consideration. Pure silver melts at 1,873° Fahr., and possesses the remarkable quality of absorbing many times its volume of oxygen when strongly heated or melted in common air. Tin melts at 442° Fahr., and when heated above this point, oxidizes very rapidly.

Under these circumstances it would, *a priori*, appear impossible to melt together silver and tin without producing the well-known results so detrimental to the alloy, since, on the one hand, during the melting the silver is rapidly absorbing oxygen, which it holds in a state of solution, as it were, and not chemically combined with itself, but to be surrendered as soon as the temperature falls; and, on the other hand, the tin is necessarily heated far above its melting point, and is consequently in a condition favorable to the most rapid oxidation, whether it obtain the necessary oxygen from its solution in the molten silver, or from the surrounding atmosphere.

The addition of gold, platinum, and some other metals to silver removes this objectionable quality of absorption of oxygen while melted, but renders a great increase of heat necessary for perfect fusion; while increased temperature still more certainly oxidizes the tin, through its unavoidable contact with common air, and thus to a great extent destroys the practical utility of such alloys. Actual experience has further demonstrated that, whatever might be the advantages gained by the addition of small quantities of either or both of these less fusible metals to a perfectly combined alloy, they are not to be attained in a purely mechanical mixture of melted metal, which requires, to prevent a separation of the constituents, while still fluid, through the agency of gravitation or affinity, an almost impossible diligence of manipulation. In fact, so numerous are the difficulties that are encountered on the very threshold of the process, that we may well question the possibility of reaching a practical solution of the problem, at least so long as the metals are to be combined by fusion.

After much consideration of the question, at once so difficult, so important, and so interesting, it has occurred to me that alloys for dental fillings, which, when in use, are necessarily under water, should if possible be formed under similar conditions. The conditions under which such alloys are usually made are so diametrically opposed to those under which they are expected to endure wear, that the above conclusion seems justifiable; for how can we expect two seemingly inert substances to retain at ordinary temperatures that kind of mutual affinity which they only display under the exceptional influence of a heat amounting to thousands of degrees? All the metals usually employed in the manufacture of dental amalgam alloys are to be found naturally combined with each other and with other metals, in varying but always definite proportions. If these alloys or combinations are the result of electro-chemical actions, under humid conditions, in the laboratory of Nature, we may reasonably hope that her processes can be imitated by the chemist, and even that they may present fewer practical difficulties than the stereotyped method hitherto solely adopted.

It has also occurred to me that an alloy for dental amalgam should be a combination of metals on other principles than those of mechanical or physical laws. There is something more to be attained than mere hardness; something else to be sought for besides brightness of color; other disqualifications to be obviated than irregular expansion and contraction. Strange as some would think it, there are qualities more sedulously to be preserved, and of more importance to the real excellence of the material, than a certain percentage of precious, infusible, injurious metals, authorizing the high sounding names that in too many instances merely cover a deficiency of the very substances claimed to be used so liberally.

My position is that alloys for dental purposes should be definite in composition, as a departure from this principle disastrously affects their durability. By a "definite alloy" I intend a chemical combination of one metal with another, excluding all mere mechanical mixtures made by weight without reference to atomic affinity. Every metal which is to enter into an alloy of this nature needs to be most thoroughly studied; its nature and behavior, both when isolated and in combination, its power of affinity for other metals, and the quantity necessary to form a saturated alloy, should all be perfectly familiar to the operator. How can satisfactory results be expected by investigators unacquainted with the laws of molecular affinity governing the formation of definite compounds through the polar attraction of atoms. I mean by "definite compound" a combination of elements, each of which loses the properties that characterized it in its isolation, to acquire new properties common to the whole, though perhaps totally dissimilar to those of the several constituents. It is, therefore, quite plain, that each metal entering into the formation of an alloy for dental purposes must have a special part assigned it in establishing and maintaining the chemical and electrical equilibrium of the

* It was the intention of the author to read this paper at the Southern Dental Convention in Atlanta, but ill-health prevented.

mass. Each atom of metal should be completely saturated by the attraction of some other atom of the other metals entering into the composition, so that its affinities may be completely satisfied and set at rest. Alloys formed upon these principles have physical properties so distinct and in many cases so vastly different from those of their constituents, whether separately or in mechanical mixture, as to mislead the closest observer. On the other hand, mixtures of metals not governed by these laws do not form saturated or even definite compounds, and are therefore for the most part as readily separable into their original simplicity as in the well-known example of iron filings mixed with sulphur, out of which composition, as every one knows, the iron can be drawn with a magnet; yet let the mixture be subjected to a certain temperature at which chemical union takes place, for a certain time, and we have a distinctly different and saturated chemical compound as a result. The iron is no longer attracted by the magnet, nor is the sulphur soluble in sulphide of carbon, so that the simple mixture has become a definite combination again.

"When a clean piece of sodium" (I quote from Essig's "Dental Metallurgy") "is rubbed in a mortar with dry mercury, the former dissolves and a peculiar seething sound, resembling that caused by the immersion of a hot body in water, is produced, due to the evolution of heat which accompanies the combination, the mercury rising rapidly in temperature as the pieces of sodium are added. As the mercury cools, the resulting alloy, which is brilliantly white, crystallizes in long, needle-like forms from the middle of the liquid, and the excess of mercury may be poured off." Now, in this place, the mercury is plainly in excess, and what takes place in consequency, *i. e.*, the complete separation by crystallization of the alloy from the uncombined metal, would also become apparent in other cases of indefinite compounding, if the metal in excess were only liquid at ordinary temperatures, so as to be decantable like mercury. But we must not suppose that the solidification of the excess would have any influence upon the crystallization of the compound. I may quote the same author's example:

"The tendency on the part of the metals to unite in definite proportions may be studied in connection with platinum, iridium, gold, rhodium, ruthenium, and silver, when fused with tin. If the latter metal is in excess after cooling, a metallic ingot is obtained resembling closely the original substance; but by the action of strong hydrochloric acid the excess of tin may be dissolved, leaving crystals of a definite alloy of the tin and the noble metal, which cannot be further dissolved by the same acid, but which are soluble in nitrohydrochloric acid, even when the precious metal contained, whether rhodium, ruthenium, or iridium, is in the free state absolutely insoluble therein."

We have here an example of a definite alloy in which each constituent loses its individual characteristics and acquires new ones peculiar to the compound. Now, supposing the alloy in the experiment to consist of tin and silver, its formation would take place by molecular union, which in its turn would occur in accordance with the various laws regulating such combination, and particularly with the principles of atomic affinity. A molecule of silver is of the same size as an atom, or, in other words, the molecule is indivisible. Silver is, therefore, a molecule of non-atomic affinity (univalent) uniting with a molecule of tin (quadrivalent) in the proportion of four to one. We accordingly, for illustration, represent a molecule of silver by a parallelogram with a single point in the center, thus $\boxed{\bullet}$, and a molecule of tin by a similar parallelogram containing four points or centers of attraction, thus $\boxed{\bullet\bullet\bullet\bullet}$, replacing as a molecule four atoms of hydrogen, and hence termed a "tetratomic" or "quadrivalent" molecule. Therefore, in the case before us the definite compound of tin and silver will be represented by the following figure or one molecule of tin saturated by four of silver. On this principle must all definite compounds or alloys of these (and the other) metals be prepared, or, as is the case in the experiment under consideration, the excess of either constituent may be demonstrated to exist uncombined.

Now, all are familiar with the various metals commonly used in making amalgams and the proportions commonly employed; and I do not require to ask a question, which, as it were, carries its own answer, whether it would be possible to obtain a definite compound by uniting metals, in promiscuous proportions, and with disregard of such laws of union as we have seen to exist.

Silver, as we have already observed, is monatomic or univalent ($\boxed{\bullet}$). Tin and platinum are alike tetratomic or quadrivalent ($\boxed{\bullet\bullet\bullet\bullet}$). Gold is triatomic (trivalent) ($\boxed{\bullet\bullet\bullet}$), copper and mercury are alike of the class of biatomic (bivalent) metals, and are represented by the sign ($\boxed{\bullet\bullet}$). When definite chemical intercompounds are expected of these metals, these facts should be kept in mind, in order that by utilizing every point of union no atom is left free, unsaturated, and prone to be acted on by new agents as if isolated; that the very affinity should be at rest and the mass be in absolute harmony—a harmony as complete as the most perfect chord of music.

The failure of so many compositions is evidently due to a want of this very harmony of composition, the component parts not being in proportions that favor atomic equilibrium; and those molecules of metal not saturated to the extent of their affinity are free to unite with any other active unsaturated molecule, or to decompose any suitable compound that they meet, and in many cases by this union set agents free which immediately attack the tooth.

It was, then, due to a thorough appreciation of the principles involved and the objects which were to be attained, that I mapped out for myself a new line of thought in reference to the whole matter of dental amalgam alloys. Figuratively speaking, I had waded through the pathless morass of speculative mixtures, finding not one to suit my purpose, so that I saw, if I must use the material, I had to try my own hand at making it, in the hope of producing something fit for use. It was evident that an alloy was what was required, and the chief question that presented itself was, "How shall I effect a combination of metals?" "Combination is favored," says an eminent French chemist,* "by heat, light, electricity, the nascent state, attractive force, bulks, and a certain active property." As we have seen that heat is injurious to alloys of the kind under consideration, and being familiar with some of the powers of electricity, I determined to attempt to produce my alloy by the process of electrolysis. Success was by no means the work of a day, even after the conception of this idea; for many difficulties were to be overcome before results of an encouraging nature were arrived at. Even then a long series of experiments was required. I am pleased to acknowledge in these experiments the kindly assistance accorded me by some of the most eminent chemists in this country and Europe, which was secured in order to arrive at anything at all satisfactory. Even after a promising result had been attained, practical considerations forced a sacrifice of some qualities obtained, in order to utilize others more essentially important, since by the isolation of these absolute permanence and durability seemed assured.

I shall not now enumerate the various experiments or modes of procedure by which we finally succeeded, but merely intimate that the principles governing electro deposition of metals were employed by us, and success was due to a complication of apparatus for distribution of the current, which resulted in depositing from a chemical bath definite quantities of the metals held in solution, in such a manner that the strength of the solution was continually kept up by the same electric current.

And now to the practical results and the physical properties of the alloy produced, which is precipitated in the requisite quantity of mercury, adjusted in the bath by scales, which turn the beam and break the current when the definite deposition has taken place. We thus obtain a standard quality of alloy, which, by a proper process, is then reduced to an impalpable powder, in which state it is ready for consumption. This compound has now been practically in use and under observation for some years, and I have never seen a case of failure, or of discoloration of tooth structure, though its agency. When used without removing surplus mercury—a little of which is provided for greater ease and convenience of manipulation, and to have the mass of any required consistence—it is found to adhere to the walls of the cavity like cement. It is the only amalgam known that will adhere to a burnisher—which it will do in its soft state—permitting that instrument to be used to convey it to the cavity. When it is intended to be used on grinding surfaces, or where exposed to severe attrition, it may be made almost as hard as adamant by pressing out all superfluous mercury and packing with warm instruments. When it is to be used over exposed and capped nerves, where we may be necessitated to remove it before long, if permitted to retain the excess of mercury, it will set very soft, thus permitting its easy removal. It has many qualities of great value, but not the least recommendation, in my eyes, is that so far I have not seen a failure. I have not the slightest hesitation in saying that it is the only amalgam I know that will absolutely preserve, and not discolor, the tooth. In some mouths the filling turns quite black, but the tooth is never discolored.

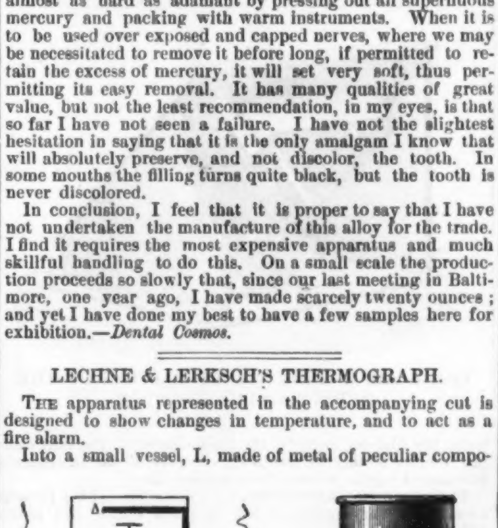
In conclusion, I feel that it is proper to say that I have not undertaken the manufacture of this alloy for the trade. I find it requires the most expensive apparatus and much skillful handling to do this. On a small scale the production proceeds so slowly that, since our last meeting in Baltimore, one year ago, I have made scarcely twenty ounces; and yet I have done my best to have a few samples here for exhibition.—*Dental Cosmos.*

* M. Naquet.

LECHNE & LERKSCH'S THERMOGRAPH.

THE apparatus represented in the accompanying cut is designed to show changes in temperature, and to act as a fire alarm.

Into a small vessel, L, made of metal of peculiar compo-



LECHNE AND LERKSCH'S THERMOGRAPH.

sition, is poured a definite quantity of mercury, H. A tube of the same metal enters this vessel through a hermetical packing, and is so fixed as to almost touch the bottom. When the temperature rises, the air expands and causes the mercury to mount into the tube. In the latter there is placed an ivory float that carries an aluminum wire surmounted by a strip of platinum, which closes an electric circuit when it abuts against platinum contact, A. The lower the vessel, L, is placed, the higher the strip of platinum will have to rise to reach the contact, A, and, consequently, the higher the temperature will have to be to bring about a closing of the circuit. This stated, it is easy to imagine a combination through which a signal shall be obtained, at any temperature whatever, upon varying the height of the vessel, L, which is provided with an index that travels over a scale whose degrees correspond to the different temperatures.

A second, and movable, contact, shown by dotted lines in the figure, serves to signal depressions in the temperature, and the bell connected with it, and interposed in the circuit, has a different tone from the arc connected with the preceding. The apparatus are regulated to a mean barometric height, and, in industrial applications, no account need be taken of the influence of variations in the pressure of the atmosphere. The apparatus are completed by the addition of a regulating device.

Every part of the instrument is of metal, and herein it possesses an essential advantage over glass apparatus, which break under the influence of a sudden variation in the temperature such is produced by a fire that breaks out all at once, and which are therefore incapable of operating precisely at the moment of danger.

The thermograph is applicable in cases where it is desired to keep the temperature of any space whatever below a certain limit, such, for example, as 30, 40, or 50 degrees. It is only necessary to place the index upon the degree that corresponds to the maximum of temperature that is not to be exceeded in order to obtain an electric signal as soon as the temperature rises, be it only one degree, above such maximum.

The double thermograph indicates in the same way a depression of the temperature below any limit whatever. The apparatus may therefore be employed for stoves used in drying inflammable materials, wood, and woolen, and for matting. In case there are several stoves, the apparatus indicates the corresponding number.

If the apparatus is to operate only as a fire alarm, the lower screw is done away with, and the vessel, L, is provided with a screw that permits the air to slowly flow in and out. In this case the apparatus requires no regulating, for it is insensible to normal variations in the temperature, and only gives warning of fires.—*La Lumiere Electrique.*

ON THE MAGNETIC SUSCEPTIBILITY AND RETENTIVENESS OF IRON AND STEEL.

By J. A. EWING, B.Sc., F.R.S.E., Professor of Engineering in University College, Dundee, formerly Professor of Mechanical Engineering and Physics in the University of Tokio.*

DURING three years the writer has been engaged, while in Japan, in prosecuting researches on the magnetization of iron and steel, and on the effects of stress on magnetic susceptibility and thermo-electric quality. Preliminary notices of some of his earlier results have appeared in the "Proceedings of the Royal Society," but a detailed account of the work has still to be given. Meanwhile, the following points, not previously noticed, are perhaps of sufficient interest to justify their separate publication.

In the experiments on magnetization, iron and steel wires were used, either welded into rings or in the form of straight pieces of such great length that the influence of the ends was negligible. Curves were obtained, in some cases by the ballistic method, and in others by the direct magnetometric method, showing the changes of magnetization which occured when magnetizing force was gradually applied, withdrawn, reapplied, reversed, and so on.

The results of many experiments with several specimens of carefully annealed soft iron wires have shown that they possess in very high degree a property not generally credited to soft iron—the property of remaining strongly magnetic when the magnetizing force is removed.

As an example, the case may be cited of an annealed iron wire which was subjected to a magnetizing force of 22·4 C.G.S. units. This gave it a magnetic induction amounting to 16,000 C.G.S. units. When the magnetizing force was gradually and completely removed, the induction fell only to 15,000 units. In other words, the intensity of residual magnetization was equal to nearly 1,200 C.G.S. units.

Here more than 93 per cent. of the whole induced magnetization survived the removal of the magnetizing force; while in many other cases the residual magnetism amounted to nearly 90 per cent. The somewhat extraordinary spectacle was thus presented of a piece of soft iron, entirely free from magnetic influence, and nevertheless holding (per unit of its volume) an amount of magnetism far in excess of what is ever held by permanent magnets of the best tempered steel.

In this condition, however, the magnetic character of the iron is highly unstable. The application of a reverse magnetizing force quickly causes demagnetization; and the slightest mechanical disturbance has a similar effect. Gentle tapping removes the residual magnetism almost completely. Variations of temperature reduce it greatly, and so does any application of stress. On the other hand, if the iron be carefully protected from disturbance, it seems that the residual magnetism disappears only very slowly, if at all, with the mere lapse of time.

If, after magnetization, the magnetizing force be removed suddenly, the residual magnetism is, as might be expected, less than if the force be removed gradually.

The ratio of residual to total magnetization is always small when the intensity of magnitization is small, and passes a maximum when the intensity is increased. This maximum is particularly distinct in wires which have been hardened by stretching; but it also occurs in soft annealed wires. In one instance, where the wire had been hardened by stretching, the maximum ratio of residual to total magnetism was 0·60, which was given by the application of a magnetizing force of about 10 C.G.S. units; but after the application of a force of 90 units the ratio fell to 0·33. In steel the maximum in this ratio is less sharp, but still distinct. Neither in hard iron nor in steel is the ratio, even at its maximum, so great as it is in soft iron, where (as has been said) it frequently reaches 0·9.

During the magnetization of soft-iron wires the greatest ratio (κ) of intensity of magnetization (I) to magnetizing force was generally about 200, sometimes nearly 300. And by gently tapping the wire during the application of magnetizing force, this coefficient was on one occasion raised to the enormous value of 1,590. In the case alluded to the magnetization went on so rapidly as the magnetizing force was increased, that a force of 1 C.G.S. unit gave an induction of 10,000.

In this and other particulars the experiments have been strongly confirmatory of the idea that there is in soft iron a static frictional resistance to the rotation of the magnetic molecules, which is the principal cause of the remarkable retentiveness described above, and which is overcome by gentle mechanical agitation.

Numerous measurements have been made of the energy expended in taking iron and steel through cyclic changes of a magnetization. For example, in changing the magnetism of a specimen of annealed iron wire from I=1,250 to I=—1,240, and back, the amount of work done against magnetic friction (apart from any induction of currents) was 1,670 centimeterdynes per cubic centimeter of the metal. In hardened iron, and especially in steel, the work done is much greater.

The effects of stress on existing magnetism and on magnetic susceptibility have been investigated at great length. The most remarkable effects occur in wires which have been hardened by stretching. In them the presence of a moderate longitudinal tensile stress increases the magnetic susceptibility immensely at low values of the magnetizing force, but diminishes it at high values. It also increases very greatly the ratio of residual to temporary magnetization. Each of these effects passes a maximum when the stress is sufficiently increased.

* Read before Section A of the British Association at Southport, 1883.

The whole subject is much complicated by the presence of the peculiar action which in previous papers the writer has named *hysteresis*, the study of which, in reference both to magnetism and to thermoelectric quality, has formed a large part of his work.

AMPEREMETERS, VOLTAMETERS, AND MEASURERS OF ENERGY AT THE VIENNA EXHIBITION.

MEASURING apparatus were well represented at the Vienna Exhibition. The attention of constructors seemed to have been especially directed toward amperemeters and voltameters designed for use in the industrial applications of electricity.

The apparatus of this kind that was most frequently found in the different exhibits was that of Mr. Marcel Deprez. Various modifications of this apparatus, constructed either by Mr. Carpentier, Briquet, or German makers, figured at the exhibition, but there was remarked besides, in Mr. Carpentier's show-case, a very practical model of this apparatus, designated under the name of the Deprez-Carpentier galvanometer, and which has not as yet been mentioned in our columns.

This type is represented in Figs. 1 and 2. Fig. 1 gives an

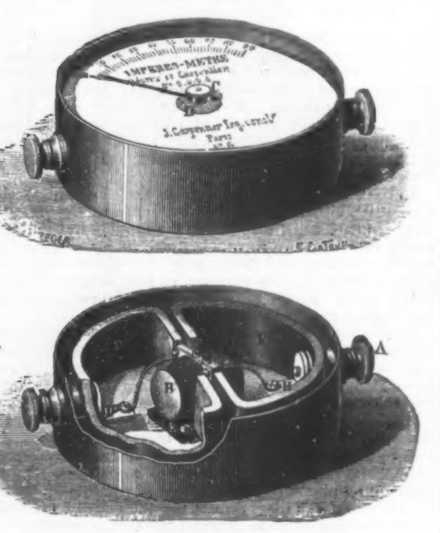


FIG. 1 ET 2

FIGS. 1 AND 2.—DEPREZ-CARPENTIER GALVANOMETER.

external view of it, and Fig. 2 represents the bottom of the box removed and the dial turned upside down.

The magnetic field is formed by two semicircular magnets, FF', exactly like one another, and the identity of which has been verified by means of a magnetometer. The soft iron needle, which is movable around an axis, M, is placed between these two poles in the interior of a double bobbin, B, and controls an index. The wires or strips that connect the bobbins with the terminals, AA', have a length such as to permit of turning the double bobbin and causing it to make different angles with the line of the poles. This movement, which is made at the time of regulating the apparatus, by the constructor, is obtained by revolving, by means of a key, the entire upper disk of the galvanometer, which is fixed in the box by hard friction only. Mr. Carpentier has had the kindness to furnish us with some interesting data in regard to the construction and regulation of these apparatus.

For the amperemeters the bobbins are formed of long strips of copper 10 mm. in width. The thickness varies according to the apparatus. In thirty amperes, for example, the thickness is 0·8 mm., and for 50, 0·13 mm This makes for the first a section of 8 and for the second 13 square millimeters. For the two bobbins there are in all 18 revolutions of the strip for the first and 14 for the second. For 80 amperes the resistance is about 0·004 ohm, and for 50 0·002. The thickness of the strips for the other models is proportioned in the same way. In graduating, each model of the amperemeter is submitted, for different inclinations of the bobbin, to currents of known and increasing intensity, the corresponding deviations are noted, and for each case the curve of intensities that correspond to the deviations obtained is traced from curves, for example, like these shown in Fig. 3. Curve No. 1 corresponds to the bobbin without inclination,

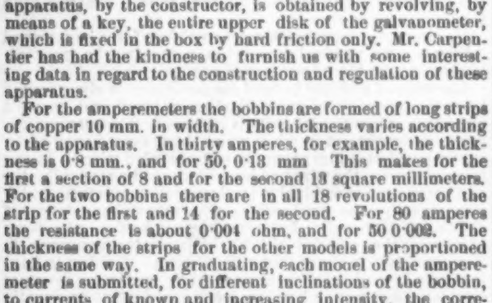
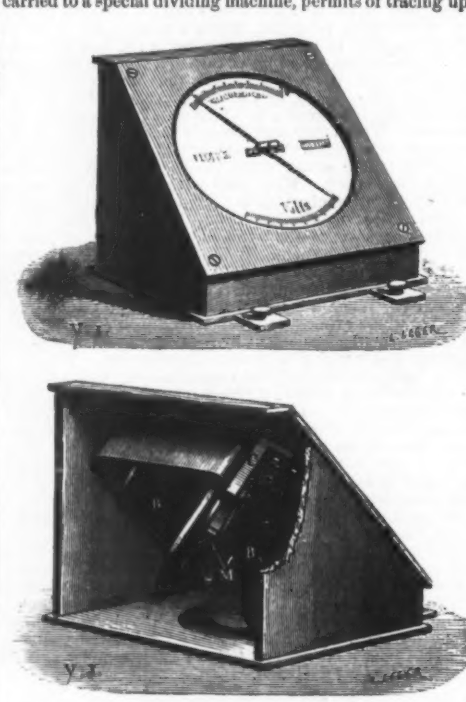


FIG. 3.

No. 2 to the bobbin inclined 10°, for example, No. 3 to a still greater inclination, say 20°. The inclination inflexes the curve, and gives the apparatus sensitiveness. We then try to ascertain at what inclination the curve most nearly approaches a right line within the limits of the deviation (from A to B), and we choose definitely the inclination corresponding to such curve. Thus, in the above curves, we would take No. 2 and incline the bobbins 10°, and on tracing in the angle of 60°, which corresponds to 30 amperes, the division in ampereres, we should have quite regularly spaced lines. It is easy to see that with curve No. 1 the 60° would correspond to 38 amperes, but the lines would cluster together on the side of strong intensities. With curve No. 3 the arc would correspond, on the contrary, to 22 amperes only, and the line slightly crowded at the origin of the graduation, would separate more than was necessary at the other extremity.

As a general thing, the inclinations of the bobbins vary from 15° to 20° in the different models. The bobbin must not be inclined too much, for, on considering curve No. 3, it will be seen that between p and q they too nearly approach the horizontal; so the indications of the needle would not be well established. The inclination to be given the bobbin having once been determined, the galvanometer is tared. To effect this, currents of known intensity are caused to pass again, the divisions in degrees corresponding to those intensities are read upon a marble dial, and the curve of the apparatus is accurately traced as above. This curve, carried to a special dividing machine, permits of tracing upon



FIGS. 4. AND 5.—FEIN'S MODIFICATION OF THE DEPREZ GALVANOMETER.

paper the dial designed for the amperemeter. The dial once put in place so that its zero well corresponds to the index's position of repose, is fixed by a flat nut, D.

The voltameters have bobbins of copper wire of 0·1 possess a resistance varying from 1,500 to 2,000 ohms, and reach 100 volts.

Mr. Carpentier adds to his amperemeters derivation bobbins which he styles "reductors," a happy expression which advantageously replaces the word "shunt" borrowed from the English. These reductors are in the form of copper boxes like the apparatus itself. They are placed under the amperemeter, and the terminals of the two apparatus are connected paralleily. Each reductor contains but a single resistance, equal to that of the galvanometer, or half less. It is necessary to say, however, that, as the amperemeters themselves have a very feeble resistance, it is very difficult to regulate the reductors exactly, and the use of them is not advisable. But it is otherwise with voltameters whose resistance is very great, for in this case the box of the reductor is so constructed that its resistance is added in series to that of the galvanometer.

Figs. 4 and 5 represent another type of Deprez galvanometer that figured at Vienna in the exhibit of Mr. Fein, of Stuttgard. Fig. 4 shows the general form of the apparatus arranged like a desk, and Fig. 5 represents the interior. The magnetic field is formed of two magnets situated in different planes. The needle of soft iron, which has its axis at *m*, is held between the two bobbins, B B. The apparatus is, as may be seen, only a modification of the preceding.

Messrs. Kapp & Crompton's amperemeters (Fig. 6) are also on the principle of directing magnets. A small magnet, A,

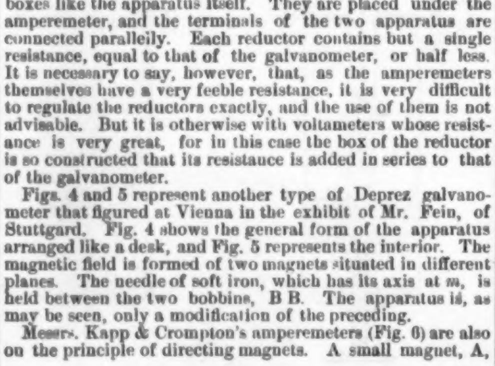


FIG. 6.—KAPP & CROMPTON'S AMPEREMETER.

that actuates an index, I, is placed between the poles of two curved electro-magnets, EE. The current traverses a strip, L, forming part of a sort of box, BB, reaches F, traverses the two electros and the strip, L, and makes its exit at T. It produces of itself, then, the directing magnetic field. The upper part of the apparatus, including the small box, H, which contains the directing magnet, may be taken off in one piece, thus allowing the internal communications to be verified.

We now come to a series of apparatus based upon different principles. We shall first cite that of Messrs. Egger and Kremenesky (Fig. 7), which is formed of an electro-magnet whose expanded poles form the cheeks. In the interior of this electro there is a spiral spring which holds at the zero point of the scale an index that terminates beneath in a small magnet nearly as long as the electro, and consequently capable of being influenced by its two circular poles. The axis of rotation of the movable system is made slightly eccentric, so that the passage into the electro of stronger and stronger currents produces increasing deviations of the needle. The apparatus is graduated experimentally according to the resistance given to the electro. It constitutes an amperemeter or a voltameter.

Mr. Uppenborn's amperemeters and voltameters are based upon the action exerted by a simple electro-magnet upon a sort of iron eccentric, M, fixed upon the same axis as the index. This eccentric is balanced in such a way that when at rest the index is at zero, and, under the influence of stronger and stronger currents, the greater and greater at-

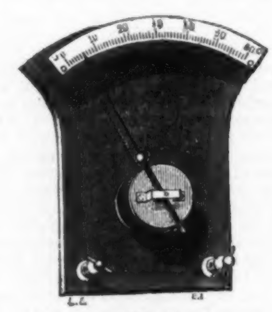


FIG. 7

FIG. 7.—EGGER & KREMENESKY'S AMPEREMETER.

traction of the electro upon the eccentric brings about increasing deviations of the index. The graduation is produced empirically. Fig. 8 represents the amperemeter; as for the voltameter, the construction is the same in principle, but the apparatus comprises, in addition, two resistance bobbins designed for modifying its range. We now come to apparatus based upon the action of a solenoid upon a core of soft iron. One of these apparatus, due to Mr. Clerc, was shown in the sun lamp exhibit. It is represented in Fig. 9, and the operation of it is easily comprehended. Upon a horizon-

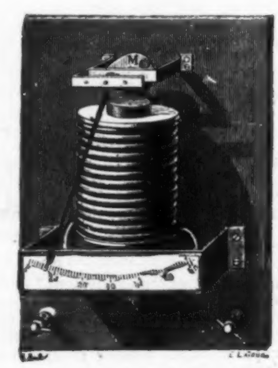


FIG. 8

FIG. 8.—UPPERBORN'S AMPEREMETER.

tal axis there is fixed, on the one hand, a short lever carrying the core of the solenoid, and, on the other, an index, I, provided with a counterpoise and a rod, C, that likewise carries a counterpoise. The counterpoises are so regulated that when no current is traversing the apparatus the index corresponds to the zero of the scale.

As the action of the solenoid, in measure as the core enters it, does not vary like the intensity, the variation is compensated for by means of the inclined rod, C. In measure as

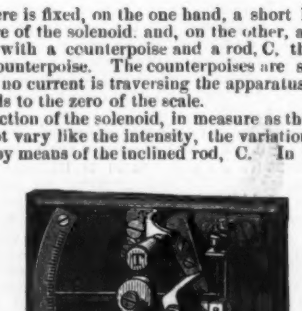


FIG. 9

FIG. 9.—CLERC'S AMPEREMETER.

the latter rises, the lever upon which the counterpoise acts varies equally and compensates for the variation of the magnetic action, so that the indications of the needle, I, became perceptibly proportional to the intensities. S and T are screw keys designed for opening and closing the circuit.

Another application of the solenoid is shown in the arrangement devised by Messrs. Piette & Krizik (Fig. 10). Two equal solenoids act inversely upon two cores that form the two sides of a parallelogram movable upon two axes. To the upper axis there is fixed an oblique rod that carries a

counterpoise and an index. The oblique position given to the rod and counterpoise performs the same role as the oblique rod and second counterpoise of the preceding apparatus.

Measurers of Energy.—Measurers of energy are always at the present time apparatus giving the product E I. Two of these apparatus, one exhibited by Sir William Siemens and the other by Messrs. Siemens & Halske, were shown at Vienna. The first we have already described, so we have only to occupy ourselves with the second, which is represented in Fig. 11.

Upon the current whose energy it is desired to measure, there is put in derivation an electro, E, wound with fine wire, and the core, A, of which is magnetized proportionally to the difference of potential, E. On another hand, there is interposed in the principal current a resistance in wire, whose extremities communicate with two bobbins, B B, that are movable around A. The current is let in by two spirals that serve, in addition, to give the bobbin arrangement a definite zero position. The current in B B is, then, a function of the intensity, I. When the current is passing at E and

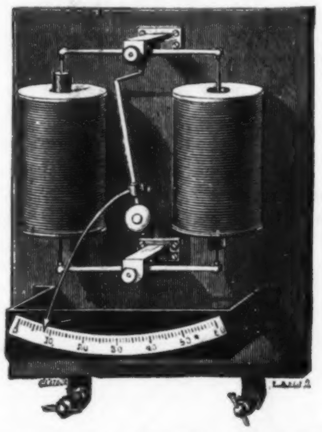


FIG. 10.—PIETTE & KRIZIK'S AMPEREMETER.

B B, the couple produced is proportional to E I, and the bobbin arrangement, B B, is deflected until the spiral springs oppose to it a torsion couple equal to that which produced the variation.

A clock, H, causes a current to pass into the apparatus every minute, the bobbins are deflected, and, at the same time, their axis, F, is caught by a gearing, M, which actuates a revolution counter. This latter gives, then, the sum of the bobbin's deviations, and, if we allow that the current is constant during each period of one minute, it follows that the counter totalizes the energy expended.

For the different intensities of the principal circuit, the resistances introduced into the circuit are made to vary. The resistance contained in the box, R, is added to that of the bobbin, E, when we have to do with differences in potential of from 100 to 1,000 volts.—*La Lumiere Electrique.*

CLAMOND'S NEW INCANDESCENT GAS BURNER.*

SOME time ago we gave a description of an incandescent gas burner, invented by Mr. Chas. Clamond, in which the refractory substance constituting the luminous body was raised to a high temperature by first highly heating the air designed to feed the flame that impinged against the incandescent substance. The use of these burners effected a great saving in gas while at the same time giving the light certain qualities of steadiness and color. In fact, the consumption was reduced to 43 liters per hour and per Carcel burner in the 4 Carcel type, and to 28 liters per hour and per Carcel burner in the intensitive type where total luminous power reached 18 burners.

Unfortunately, however, such a saving in gas was too dearly bought. It was necessary, in fact, to have passageways for the air parallel with those for the gas, and the volume of air that these had to furnish was about six times greater than that of the gas consumed, while the pressure of the air had to be kept at or above 40 millimeters of water. This double passageway, which was sufficient of a complication in many cases, became still more complicated through a system of compressing the air which, according to circumstances, required either a compressing pump actuated by the general shafting of the works in which the lamp was used, or by a small gas motor (Otto or Bishop), or, finally, in less important applications, by a blast apparatus run by weights, capable of operating several hours, and wound up every evening by means of a winch.

It is very evident that all these complications, inherent to the above named system, singularly retarded its development, and so it became necessary to free it from them at any price. Mr. Clamond was the first to see the necessity of this, and his researches, which are to-day crowned with success, have for the last two years been solely directed toward this end.

The successive modifications that have been made in the incandescent burner have completely solved the problem, and it is the solution under the last form given by Mr. Clamond that we now desire to lay before our readers.

Fig. 1 gives a general view of the burner surmounted by its glass chimney, and Fig. 2 shows a longitudinal section that will permit its arrangement and operation to be understood.

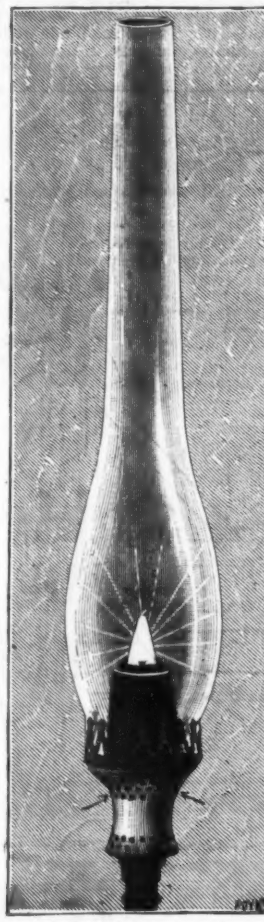


FIG. 1.—CLAMOND'S NEW INCANDESCENT GAS BURNER.

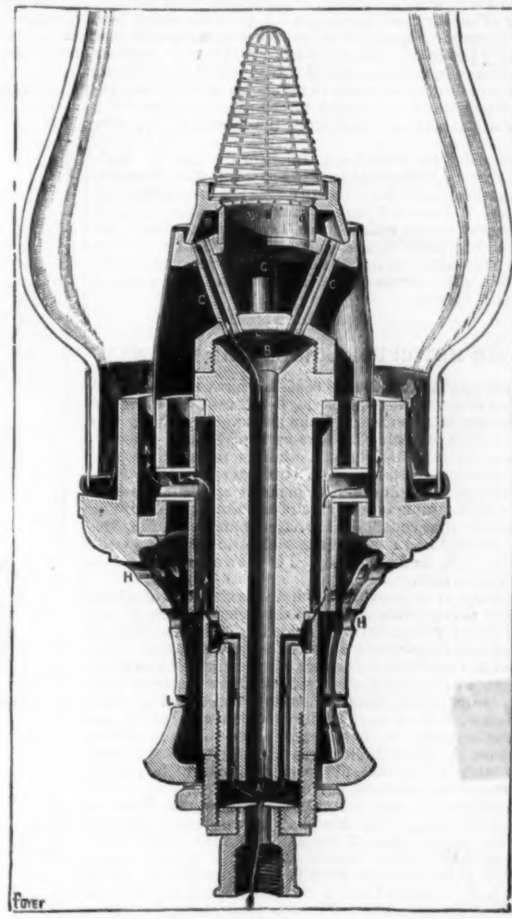


FIG. 2.—LONGITUDINAL SECTION OF THE BURNER.

The following is the author's description of his new burner:

"It consists of three distinct parts, to wit: The first is a central column of refractory material containing conduits so arranged as to supply gas to the interior part that is designed to heat the air, and to the upper part designed for the incandescence of the magnesium.

"The second part, which surrounds the first, consists of two concentric cylinders connected by hollow cross-pieces that put the interior of the smaller cylinder in communication with the exterior of the larger.

"The third part contains the two others, and is a porcelain jacket containing properly spaced apertures.

"The first combustion occurs in the annular space included between the first two parts, and its products make their exit eccentrically through the hollow cross-braces. The object of this is to raise to a red heat the interior tube of the second part.

"The air enters through the apertures in the external jacket, strikes this incandescent tube, becomes highly heated upon contact therewith, and rises toward the upper point of combustion, where the gas jets are arranged in such a way as to give small independent flames, each enveloped by a current of hot air and effecting their complete combustion in the interior of the magnesia basket."

It is easy to see, by reference to Fig. 2, how the different parts of the burner are arranged in practice. The lower part of the burner is screwed to the upper part of the bracket tube, and is simply substituted for the ordinary butterfly, Argand, etc., burners.

The gas enters at A, and divides into two portions. One of these debouches at the lower part of the magnesia basket in subdividing, first, in the conical chamber, B, and the tubes, C, and next in the annular chamber, D, and the apertures, *a*. The second portion makes its exit through the vertical tubes, E, escapes through F, and burns in G, through the air coming from the lower part of the burner through the apertures, L. The products of combustion escape through a series of horizontal tubes, J (this letter is reversed in the figure), the annular space, K, and the glass chimney, and thus heats the entire mass of the burner.

The air for supplying the ring of apertures, *a*, that serve to heat the magnesia basket and render it incandescent, enters through the apertures, H, impinges against the tubes, J, and the central part of the burner, and is thus progressively and methodically raised to a high temperature, which, according to Mr. Clamond, varies between 800° and 1,000° C. when the air enters the chambers that surrounds the tubes, C, and the annular space under the basket. These small apertures, *a*, then, constitute so many little isolated burners that are supplied with air at 1,000° C., and the products of combustion from these are of a sufficiently elevated temperature to raise to incandescence the little magnesian basket whose meshes they touch.

Upon making a horizontal section of the burner at the height of the tubes, C, during its operation, we shall find, then, three distinct circulations: (1) a circulation of hot air around the tubes, C, coming from outside through the apertures, H, heated by direct contact with the central part of the burner, and debouching into the very center of the burner and basket in order to produce the combustion of the gas issuing from the apertures, *a*; (2) a circulation of the products of the combustion of the second portion of the gas, serving to heat the air, and debouching into the chimney through the annular space, K; and (3) a circulation of the as yet unburned illuminating gas in the interior of the tubes, C, the gas entering directly from A, through the central tube.

A horizontal section made toward the middle of the magnesian basket will give two concentric currents of products of combustion, one of them due to the gas escaping from *a*, and serving to heat the basket, and the other due to the combustion of the gas employed to effect the heating of the air.

According to Mr. Clamond's memoir, the magnesian baskets are made as follows:

"In order to form this basket, I prepare a plastic paste of magnesia by mixing the latter (baked at a high temperature and finely pulverized) with a solution of acetate of magnesia of sirupy consistency. I introduce this paste into a cylinder, whence, under the pressure of a compressing piston, it flows through a draw plate in the form of a strong and flexible thread analogous to vermicelli. This thread is wound mechanically upon a conical mandrel in the direction of two planes at right angles, the different superposed spirals uniting at their points of contact.

"The baskets, once manufactured, are dried and afterward baked at a high temperature, the decomposition of the acetate of magnesia leaving a residuum of solid magnesia that agglomerates the incorporated powder.

* SUPPLEMENT No. 408, p. 6508.

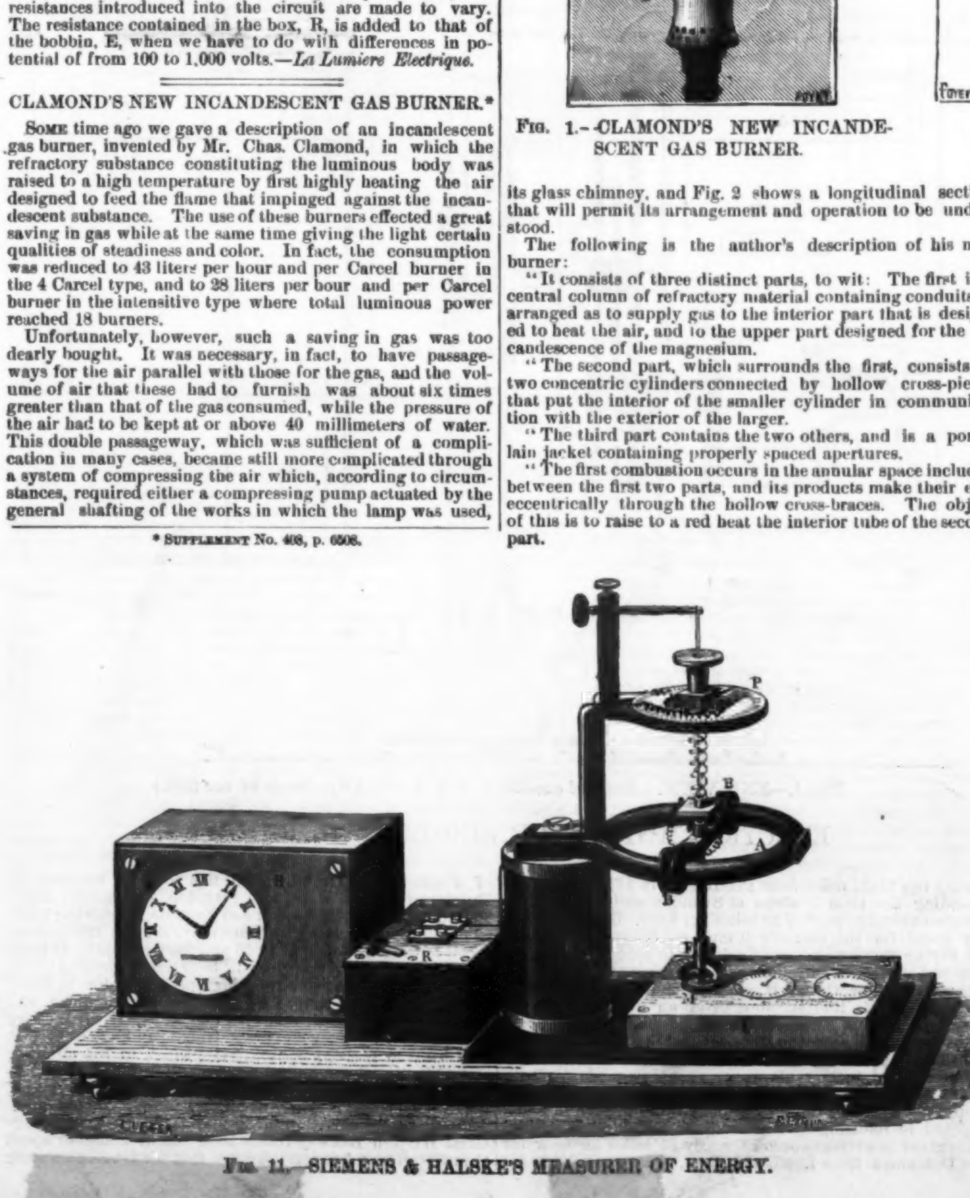


FIG. 11.—SIEMENS & HALSKE'S MEASURER OF ENERGY.

"The duration of these baskets depends upon the size of the thread, and is at least from 12 to 15 hours."

To charge them is one of the easiest of operations, since it is only necessary to place the basket upon the annular space formed to receive it.

The light given varies with the size of the place of combustion, and the burner is so much the more economical in proportion as that is larger. The 180 liter type produces the Carcel burner and represents a consumption of 45 liters only per hour and per Carcel burner. The performance, then, is clearly equal to that of the insufflation burner, which, in the 4-Carcel burner type, consumed 43 liters per hour and per unit of light.

Mr. Clamond has succeeded in suppressing the air under pressure by doing away with the makeshifts that he was obliged to introduce into his first apparatus in order to effect a heating of the air, and by using a tall glass chimney that favors a draught. Fig. 1 shows the unusual proportions that the chimney possesses. We must confess that it is neither convenient to use, nor economical, nor graceful, and that an endeavor will have to be made to reduce its dimensions, especially for elegant applications; but this is a criticism of a detail that detracts nothing from the merits of the new burner.

EXPLANATION OF FIG. 2.—A, Inlet for the gas. B, Division chamber. C, Tubes that lead the gas into the chamber, D. *a*, Apertures that form gas jets under the magnesian basket. E and T, Inlets for the gas that heats the air. L, Apertures that lead the air which burns the gas that heats the air. G, Combustion of the heating gas. J, R, Exit for the products of combustion into the chimney. H, Apertures that lead the air which burns the gas at *a*, against the sides, J and R.—*La Nature.*

ELECTRIC MOTOR FOR SINGLE-RAIL RAILWAY.

IN SUPPLEMENT, No. 420, p. 6695, we gave an illustrated description of a very ingenious single-rail railway, designed for special use in Algeria. For the last twenty months this system has been operating in some parts of France, where it has attracted much attention. As the system was not adapted for use where animal traction could not be employed, it was found necessary, in order to make it applicable everywhere, to devise some other mode of traction that should be practical as well as economical. After some reflection, Mr. Lartigue decided upon the Siemens electric motor, and the special form that he finally adopted is shown in the accompanying engravings.

The apparatus is provided with two axles, one of which carries the driving wheel, G, and the other a roller, H, designed simply for distributing the load. The dimensions of the wheels are respectively about 1 foot and 6 inches. The channel of the smaller one is about 9 inches in width to allow of its passage in curves of short radius. The distance from center to center of the axles is about two feet. The axles carry a frame, C E, of angle iron, to which are bolted and riveted the branches, A, whose extremities are supported by the iron bars, B. Upon the horizontal portion of the branches, A, are established wooden platforms, one of which receives the motor and the other the engineman.

The motor is a dynamo-electric machine of the Siemens horizontal D² type. Upon the shaft of this motor, as well as upon the prolongation of the axle, J, there are mounted three channeled pulleys that are actuated by a gut cord. The first, *r*, is keyed to the shaft of the dynamo and drives the pulley, *r'*, which is loose upon the axle, but keyed upon a sleeve with its neighbor. The two other pulleys, *r*, are in their turn loose upon the shaft of the dynamo and keyed together in such a way as to give the requisite velocity to the axle, J, of the motor. The ratios of the diameters of these three pairs of wheels are as 1 to 2, so that the dynamo makes eight revolutions while the wheel, G, is making one. The velocity of the dynamo being 1,200 revolutions per minute, that of the axle is 150, and the linear velocity corresponding is 140 meters per minute, or about from 8 to 10 kilometers per hour. On a level this velocity reaches 14 or 15 kilometers, while on up grades it falls notably below that.

The engineman sits on the opposite side, where he can easily maneuver the rheostat, the commutators for changing direction, and the brakes. The electric current is carried to the track by two conductors, one of which is connected with the rail itself and the other with a piece of hoop iron, U, insulated from the rail and parallel with it. This hoop iron is carried by rectangular pieces of iron screwed to pieces of wood, *g*, fastened to the support, *p*. From these two systems of conductors it is easy to take up the current while the locomotive is running and transmit it to the dynamo.

On the one hand, the pulleys in rolling over the rails establish a sufficient contact to allow the whole affair to give passage to the current, which is led by a cable to one of the terminals of the dynamo. On another hand, a current gatherer, consisting of two small channeled pulleys, F, carried by a jointed connecting rod, *a b*, insulated from the carriage, is in connection with a cable which forms a circuit by leading the current to the other terminal of the machine. The connecting rod is doubly jointed, thus permitting not only all the inequalities of the road to be followed, but also securing a contact therewith, notwithstanding the possible oscillations of the carriage. In order to prevent derailment of the latter, a tender is provided.

The current then is led to the dynamo by putting the wires in connection with the carriage on the one hand and with the connecting rod on the other. In order to facilitate the maneuvers, special cables, terminating at the entrance and exit terminals of the electro-magnets and bobbin, are fixed to commutators placed within reach of the engineman. The first of these commutators permits of stopping or starting the train. The two others have their levers connected with a single reversing bar, so that the two extreme positions of the latter cause the train to run backward or forward. The direction of the currents in the electro-magnets is changed at will by maneuvering the commutators. As the brushes of the dynamo are keyed to the neutral point, it follows that at every position of the commutators there will correspond a direction of rotation of the bobbin and consequently a direction of the carriage and train.

A rheostat, formed of a commutator and resistances, completes the maneuvering apparatus and permits the intensity of the current, and consequently the speed of the train, to be reduced at will. It also prevents those sudden jerks on starting that so greatly raise the intensity of the current.

All the experiments that have been made with this motor have proved a complete success. A new progress has therefore been effected, thanks to this happy application, and Mr. Lartigue as well as a number of others who are interested in his system of transportation, is convinced that the electric motor can hereafter be applied to the system and render most valuable services.—*Annales Industrielles.*

THE FASTEST TRAIN IN GREAT BRITAIN.

SOME articles have lately appeared in the monthly magazines respecting the speed of railway trains, and the following information will, says *The Engineer*, correct some misunderstanding on the subject: It has been represented that the Great Northern Scotch express is the fastest train in Great Britain, whereas the Great Western Flying Dutchman runs at a higher speed, and is still, as it always has been, the fastest train in the world. It leaves Paddington at 11:45 midday and runs to Swindon, a distance of 77¼ miles, in 87 minutes, an average of 53¼ miles per hour. After stopping at Swindon ten minutes it leaves for Bath at 1:22, arriving here at 2 o'clock, thus making a run of 107 miles in 125 minutes, an average speed of 53½ miles per hour. The Great Northern 10 o'clock express runs without any stop from King's Cross to Grantham, 105 miles, in 2 hours and 9 minutes, nearly 49 miles an hour. The Great Western Dutchman stops at Bath 3 minutes, and gets to Bristol at 2:21, having run 118½ miles from Paddington in 143 minutes, not including the time it stops at Swindon and Bath, which gives an average speed of 50 miles per hour. But in reckoning speed for this distance it must not be overlooked that the Flying Dutchman loses 4 minutes in reducing speed to stop and start from Swindon, and the same at Bath, in addition to the time while it is actually standing at the stations, and taking this into account, gives an average speed of the train for the journey to Bristol of 52½ miles per hour, to be compared with the 49 miles per hour of the Great Northern express. In order, however, to get a more correct average speed, further allowance should be made for both trains of 2 minutes for each start and the same for each stop, as at least this time is lost in getting up speed in starting and in reducing speed to come to a stand at a station. This gives an average speed of nearly 55 miles an hour for the Dutchman from London to Bath, 50 miles an hour for the Scotchman from King's Cross to Grantham, and 54 miles an hour for the Dutchman from London to Bristol. Those well acquainted with the road know that such an average speed is only obtainable by running at more than the traditional mile a minute over a great portion of the journey. The Scotch express certainly runs the longest distance, 105 miles, without stopping; but even with this advantage in regard to speed it does not travel as fast as the Great Western Railway Dutchman, which runs 2 miles more, in 4 minutes less time, with an intermediate stop, than the Great Northern Railway Scotchman takes in running a distance shorter by two miles without any stop.

Taking the comparison shown recently in a monthly contemporary—*Chambers's Journal* for December 29—of the run of the Scotch express to York, 188 miles in 235 minutes, with an average speed of 48 miles per hour including stoppages, and the Flying Dutchman's run to Exeter, 194 miles in 255 minutes, average speed 45½ miles per hour, calculated in the same manner. The Scotch express has only one stop of 6 minutes at Grantham on this journey, whereas the Dutchman has four stops, viz., Swindon, 10 minutes; Bath, 3 minutes; Bristol, 5 minutes; and Taunton, 4 minutes; total, 22 minutes. Deducting the stops only, it gives the average speed of the Dutchman to be 50 and the Scotchman 49 miles per hour; but also allowing for both trains working up to full speed in starting and reducing speed to a stop in every case, the average speed is 54½ miles for the Dutchman, and for the Scotchman 51 miles per hour. The Great Western Railway narrow gauge express from Paddington at 4:45 P.M. runs to Wolverhampton, 141½ miles, in 184 minutes; and deducting five minutes', stop at Oxford and three at Birmingham, and allowing for getting up and reducing speed, the average speed is nearly 52 miles per hour, or 50½ miles deducting stops only. In further proof that the broad gauge Great Western Railway trains have run at a higher speed than 60 miles an hour, it is known that the Dutchman some

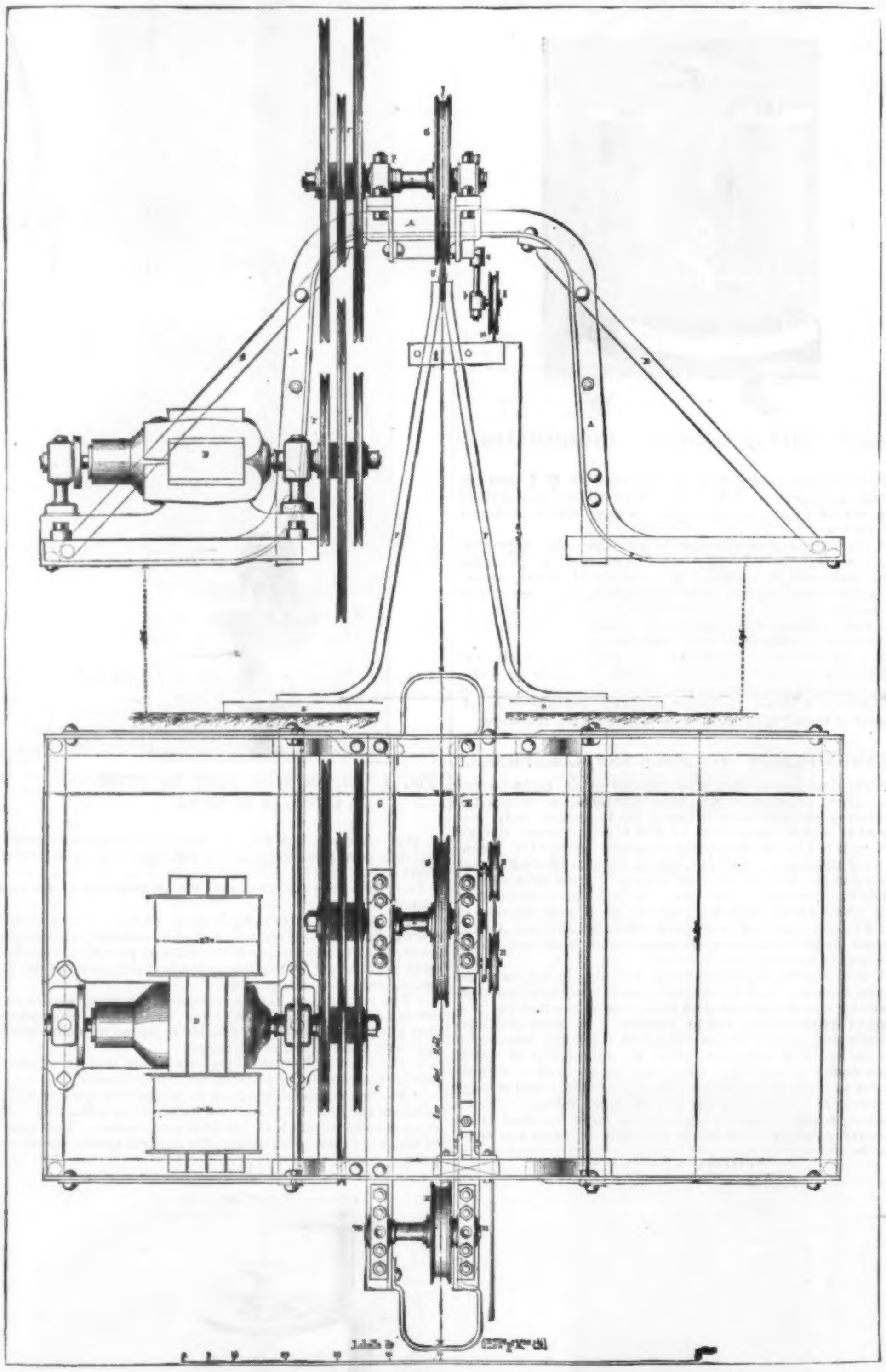


FIG. 1.—END VIEW. (Scale of one-fifth.) FIG. 2.—PLAN. (Scale of one-fifth.)

ELECTRIC MOTOR FOR SINGLE RAIL RAILWAY.

time ago ran from Swindon to Paddington, 77¼ miles, in exactly 77 minutes. A special Cape mail train also ran the same journey in 76 minutes, and the fast Zulu express train ran it in 79 minutes. The fastest journey on record is that made by the Great Western Railway 9:15 P.M. express from Paddington on the 11th May, 1848. The train consisted of the broad gauge engine Great Britain, four carriages and a van, and ran to Didcot, 53¼ miles, in 47 minutes—an average speed of 68 miles an hour. The driver was Michael Almond, deceased, and the fireman was Richard Denham, who is living at Swindon, a superannuated engineman.

These instances quoted of Great Western trains running at a greater speed than the traditional mile a minute are cases of long distances verified by official record, whereas the distances of extreme speed referred to in a contemporary are apparently only founded on the statement of a writer who says he "has acquired some facility in guessing the speed of trains by noting the mile posts," and asserts that in doing this on one occasion he noted the speed of a North Western train as 75 miles per hour for four or five miles, or at the rate of a mile in forty-eight seconds. The Great Western Railway broad gauge Flying Dutchman and Zulu express trains between London and Swindon run daily on portions of the journey—where the line is perfectly level—at more than 80 miles an hour for such short distances; and if it were not for the unavoidable stop of ten minutes at Swindon for refreshments, the Great Western Railway trains could be accelerated for a longer journey to such a speed that the great Northern express would be left further behind the "Fastest Train in Great Britain."

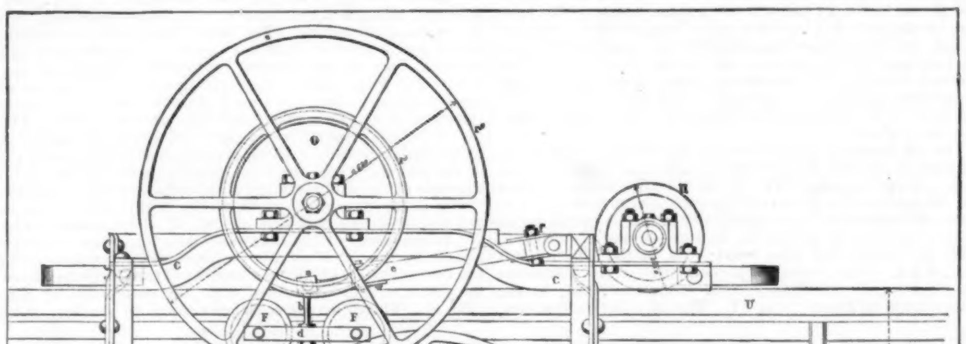


Fig. 3.—SIDE VIEW. (Scale of one-fifth.)

ELECTRIC MOTOR FOR SINGLE-RAIL RAILWAY.

THE HEAT-ACTION OF EXPLOSIVES.*

By Captain Andrew Noble, C.B., F.R.S.

The lecturer commenced by pointing out that the salient peculiarities of some of the best known explosives might roughly be defined to be the instantaneous, or at least the extremely rapid, conversion of a solid or fluid into a gaseous mass occupying a volume many times greater than that of the original body, the phenomenon being generally accompanied by a considerable development of measurable heat, which heat played a most important part not only in the pressure attained, if the reaction took place in a confined space, but in the energy which the explosive was capable of generating. Fulminates of silver and mercury, picrate of potassa, gun-cotton, nitro-glycerine, and gunpowder were cited as explosives of this class. The lecturer asserted that substances such as those just named were not the only true explosives. In these solid and liquid explosives, which consisted generally of a substance capable of being burned, and a substance capable of a supporting combustion in, for example, gun-cotton or gunpowder, the carbon was associated with the oxygen in an extremely condensed form. But the oxidizable and oxidizing substances might themselves, prior to the reaction, be in the gaseous form; as, for instance, in the case of mixtures of air or oxygen with carbonic oxide, of marsh gas with oxygen, or of hydrogen and oxygen. He added that these bodies did not complete the list, and that, under certain circumstances, many substances ordinarily considered harmless must be included under the head of explosives, making a reference to finely divided substances capable of oxidation, or certain vapors which when suspended in or diluted with atmospheric air formed mixtures which had been the cause of many serious explosions.

These instances served to show that an explosive might be either solid, liquid, or gaseous, or any combination of these three states of matter. In the first place a brief account was given of the substances of which some explosives were composed, illustrated by the composition of one or two well-known types. In the second place the lecturer showed the changes which occurred when explosives were fired, and gave the substances formed, the heat developed, the temperature at which the reaction took place, and the pressure realized, if the products were absolutely confined in a strong enough vessel, relating the experiments which had been made, and the apparatus which had been used, either to ascertain or to verify the facts required by theory. He further supposed all the explosives to be placed in the bore of a gun, and traced their behavior in the bore, their action on the projectile, and on the gun itself. He also described the means and apparatus that had been employed to ascertain the pressure acting on the projectile and on the walls of the gun, and to follow the motion of the projectile in its passage through the bore.

He mentioned that the potential engery stored up in a mixture of hydrogen and oxygen forming water was, if taken with reference to its weight, higher than that of any other known mixture, and explained why such an explosive, whose components were so readily obtainable, was not employed as a propelling or disruptive agent, the main objection being that if a kilogramme of gunpowder, forming a portion of a charge for a gun, was assumed to occupy a liter or a decimeter cubed, a kilogramme of hydrogen, with the oxygen necessary for its combustion, would at zero and at atmospheric pressure occupy a volume sixteen thousand times as great.

The lecturer next passed to gun-cotton, described its composition and the various forms in which it was manufactured, referring especially to the forms which were so largely due to Sir Frederick Abel. The various forms of gun-cotton were exploded, and the lecturer remarked on the small quantity of smoke formed, as an indication of the small amount of solid matter in the products of combustion. Also that instead of the explosions which took place when gaseous mixtures were fire, gun-cotton appeared rather to burn violently than explode. This was due to the ease with which the nascent products escaped into the atmosphere, so that no very high pressure was set up; but it was pointed out that by a small charge of fulminate of mercury, or other means, a high initial pressure was produced, and the harmless ignition shown would be converted into an explosion of the most violent and destructive character. This transformation differed materially from those which he had hitherto considered. In both of these the elements were, prior to ignition, in the gaseous state, and the energy liberated by the explosion was expressed directly in the form of heat. In the present instance a very large but unknown quantity of heat disappeared in performing the work of bringing the products of explosion to the gaseous state.

Captain Noble then showed that gunpowder, the last and most important example selected, was also by far the most difficult to experiment with, as well as the most complicated and varied in the decomposition which it underwent. One great advantage for the artillerist which gunpowder possessed in being a mixture not a definite chemical combination, was that when fired it did not explode in the strict sense of the word. It could not, for example, be detonated as could gun-cotton or nitro-glycerine, but it deflagrated with great rapidity, that rapidity varying with the pressure under which the explosion was taking place. As a striking illustration of the effect of pressure in increasing or retarding combustion, he showed an experiment devised by Sir Frederick Abel. It consisted in endeavoring to burn powder *in vacuo*, and he demonstrated that it would not burn until sufficient pressure was reached. He exhibited the various forms under which gunpowder was manufactured, and ignited some samples of powder, pointing out the essential difference between their combustion and that of gun-cotton, namely, the large quantity of what was commonly called smoke slowly diffusing itself in the air. He also exhibited a portion of the so-called smoke of a charge of 15 lb. of powder, collected in a closed vessel.

Captain Noble next described at some length the experiments made with gun-cotton and gunpowder by Sir Frederick Abel and himself. With reference to the latter he reiterated their opinion that, except for instructional purposes, but little accurate value could be attached to any attempt to give a general chemical expression to the metamorphosis of a gunpowder of a normal composition.

He further pointed out that heat played the whole *role* in the phenomena. He explained that a portion of this heat, to use the old nomenclature, was latent; it could not be measured by a calorimeter; that was, it had disappeared or been consumed in performing the work of placing a portion of the solid gunpowder in the gaseous condition. A large portion remained in the form of heat, and performed an important part in the action of the gunpowder on a projectile.

After describing the apparatus used by Sir Frederick Abel and himself, Captain Noble illustrated the progress that had been made in artillery by mentioning that thirty years ago the largest charge used in any gun was 16 lb. of powder. The 32 pounder gun, which was the principal gun with which the navy was armed, fired only 10 lb.; but he had fired and absolutely retained in one of these vessels no less a charge than 23 lb. of powder and 5 lb. of gun-cotton.

The lecturer next referred to erosion and its effects, and added that he was not one of those who advocated or recommended the use of gunpowder giving very high initial tensions. If such a course were followed, much would be lost and little gained. The bores of guns would be destroyed in a very few rounds. There was no difficulty in making guns to stand pressures much higher than those to which they were normally subjected, but then they must be in a serviceable condition. Nine-tenths of the failures of guns with which he was acquainted had arisen, not from inherent weakness of the guns when in a perfect state, but from their having, from one cause or another, been placed in a condition in which they were deprived of a large portion of their initial strength. He added that, with a given weight of gun, a higher effect could be obtained if the maximum pressure was kept within moderate limits.

He stated that the actual pressure reached by the explosion of gun-cottons experimented with by Sir Frederick Abel and himself, assuming the gravimetric density of the charge to be unity, would be between 18,000 and 19,000 atmospheres, or say 120 tons on the square inch. While at the same density, in a closed vessel with ordinary powder, the pressures reached about 6,500 atmospheres, or about 43 tons on the square inch, he had found it possible to measure the pressures due to the explosion of charges at considerably higher density, and had observed pressures of nearly 60 tons with a density of about 1·2.

The lecturer then considered the case of a charge of gunpowder placed in the chamber of a gun; he supposed the gravimetric density of the charge to be unity, that it was fired, and that it was completely exploded before the shot was allowed to move. He exhibited on a diagram a curve indicating the relation between the tension and the density of the products of combustion when employed in the production of work; and observed that in this diagram the tension was represented by the ordinates, the expansions by the abscissæ, and the energy developed by any given expansion was denoted by the area between the corresponding ordinates, the curve, and the axis of abscissæ. He said that if this theoretic curve was compared with the curve deduced from experiments in the bores of guns, after the charge might be supposed to be completely consumed, the agreement was most remarkable, and afforded ample evidence of the approximate correctness of the theory. He had stated that he could not agree with those who were in favor of the strongest—meaning by the term the most explosive—powder manufactured. To show the advance that had been made by moving in exactly the opposite direction, he exhibited diagrams of two guns of precisely the same weight, but differing in date by an interval of ten years. One of these guns was designed to fire the old-fashioned R.L.G., the other, modern powders. The maximum pressure in the older gun was nearly double that in the modern gun, while the velocity developed by the latter was twice, and the energy not far from three times, that of the former; and if the foot-tons per inch of shots' circumference were taken to represent approximately the respective penetrating powers of the projectiles, the superiority of the modern gun would be still more apparent. He directed attention, however, to one point. The new gun was as a thermo-dynamic machine much less efficient than the old. This arose chiefly from the fact that although the new gun was absolutely much longer than its rival, it was, taken in relation to the charge, much shorter; that was, the gases were discharged at the muzzle at a much higher tension.

It remained to consider the total amount of energy stored up in explosives. In the case of the most important, gunpowder, he stated that the total energy stored up was about 340,000 kilogrammeters per kilogramme of powder, or in English measure, a little under 500 foot-tons per pound of powder. He said that if the potential energy of 1 lb. of gunpowder was compared with that stored up in 1 lb. of coal, his audience, being accustomed to the enormous pressures developed by gun-powder, might be somewhat astonished at the results of the comparison. The potential energy of 1 lb. of gun-powder was as nearly as possible $\frac{1}{10}$ of that of 1 lb. of coal, and $\frac{1}{37}$ of that of 1 lb. of hydrogen. It was not even equal to the energy stored up in the carbon which formed one of its own constituents. As an economic source of power, coal had the advantage by at least two thousand to one.

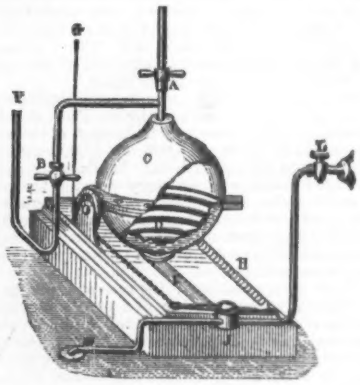
He had stated that the total theoretic work of gunpowder was a little under 500 foot-tons per pound of powder, but it might be desirable to mention what proportion of this theoretic work was realized in modern artillery. He concluded by arguing that were it necessary to urge the claims of the modern science of thermo-dynamics, he might take, as perhaps the most striking instance, the progress of artillery during the last quarter of a century. Twenty-five years ago our most powerful piece of artillery was a 68 pounder, throwing its projectile with a velocity of 1,600 ft. per second. Since then the weight of our guns had been increased from 5 tons to 100 tons, the projectile from 68 lb. to 2,000 lb., the velocities from 1,600 ft. to 2,000 ft. per second, the energies from 1,100 foot-tons to over 52,000 foot-tons. Large as these figures were, and astonishing as were the energies which in a small fraction of a second could be impressed on a projectile of nearly a ton weight, they sank into the most absolute insignificance when our projectiles were compared with other projectiles, velocities, and energies existing in nature. Helmholtz had given an estimate of the heat that would be developed if the earth were suddenly brought to rest, but if, looking at the earth in an artillery point of view, and following the principles he had laid down, the earth was considered as an enormous projectile, and if it was supposed, further, that the whole energy stored up in gunpowder could be utilized, there would yet be required a charge 150 times greater than its own weight, or 900 times greater than its volume, to communicate to the earth her orbital motion.

* Abstract of a recent lecture before the Institution of Civil Engineers.

GATTERALL & BIRCH'S HYDRAULIC LIQUID ELEVATOR.

THE apparatus shown in the accompanying cut is designed for safely lifting to an upper story such inflammable liquids as kerosene and spirits, or beverages for consumption in a perfectly fresh state. The apparatus acts by means of the pressure furnished by the city water supply, or by a reservoir. The operation of the mechanism may be understood by a reference to the cut, where A is the spherical valve of the force column; B, the valve that shuts off the liquid to be raised; C, a hemisphere containing the liquid to be raised; D, a hemisphere communicating with the water under pressure; E, a pipe leading water to the inlet at D; F, feed-pipe; G, a cord connected with a pedal; H, spring of the cock, J; L, inlet of the water under pressure; J, a three-way cock; M, scape pipe.

In an installation like this the feed receptacle must be placed high enough to supply the vessel, C, whatever be the level of the liquid. Near the discharge cock on the column, A, in the upper story there is a pedal that actuates the cord, G, through guide pulleys. Finally, the two hemispheres, C and D, which are well joined, are separated by an undulating membrane that is so constructed as to take a convex or concave form. The whole rests upon a base-plate of small dimensions. In order to operate the apparatus it is only necessary to press upon the pedal, which will cause the ascent of the liquid contained in the hemisphere, C. In fact, the cord, G, causes the key of the cock, J, to turn, and opens the latter for the admission of water at D. The water under pressure then acts upon the flexible



membrane and forces into the ascensional pipe a portion or the whole of the liquid filling the vessel, C. As soon as the pressure is removed from the pedal, the spring, H, forces the cock to assume its initial position, and during this the motive water escapes in the direction, EJM. The type that is being constructed at present is capable of discharging three liters at each complete movement of the membrane.—*Revue Industrielle.*

HYDRAULIC PROPULSION.

AT a recent meeting of the Institution of Civil Engineers, a paper was read on "Hydraulic Propulsion," by Mr. Sidney Walker Barnaby, C.E.

The idea of propelling ships by forcing water through the bottom or sides by means of pumps was suggested in 1861, which was the date of the first patent upon the subject. The Nautilus and the Waterwitch, built in 1866, attracted a good deal of public attention. The latter was an armored gunboat built for the Admiralty at the Thames Iron Works, the machinery having been designed by Mr. Ruthven. This gunboat was driven by two water jets discharged from nozzles at the sides level with the water, the diameter of each of which was 24 inches. The jets were supplied by a centrifugal pump, 14 feet in diameter. The quantity of water discharged per second was 5·2 tons, at a velocity of 29 feet per second. When the engines were developing 760 indicated horse power, the vessel, which was of 1,161 tons displacement, attained a speed of 9·3 knots. The Viper, a similar vessel but driven by a screw propeller, with a displacement of 1,180 tons, attained a speed of 9·58 knots, with 696 indicated horse power.

Although this pointed to a considerable waste of power by the hydraulic system, many people thought it had not received a fair trial; and Lord Dufferin's committee on designs of ships of war in 1871 recommended that, in view of its suitability for draughts of water so small as to preclude the use of screws, it should receive a more thorough trial. In 1878 a hydraulic torpedo vessel was built in Sweden for competition with a similar vessel propelled by twin screws. The vessels were 58 feet in length, with 10 feet 9 inches beam, and of 20 to 21 tons displacement. The screws with 90 indicated horse power drove the boat at a speed of 10 knots, while the turbine, with 78 indicated horse power, gave a speed of 8·12 knots per hour. The displacement coefficients were 82 with the screw, 52·5 with the turbine.

The Fleischer hydromotor, built in Germany in 1879, also failed to compete with the screw in point of economy. In this vessel there was no centrifugal pump. The steam acted directly upon the water, forcing it out of vertical cylinders through nozzles in the bottom of the vessel, which could be turned in any direction. The motion was unpleasant, owing to the intermittent action of the jets, and the speed obtained was small. The advantages which the hydraulic system of propulsion presented might be enumerated as follows: No impediment to speed under sail; no racing of the engines; power of reversing motion in the hands of the officer on deck; full engine power for maneuvering; vessel capable of being made double ended; and power of ramming much increased. The propeller was not liable to receive damage from running aground, and could not be fouled by floating obstructions; it was favorable for light draught, and the large pumping power was available for keeping down leaks. The disadvantages were mainly these: The difficulty of utilizing the full energy of the water entering the propeller; every particle of water acted upon must be carried in the ship; loss by friction of the water in the passages and by bends in the pipe.

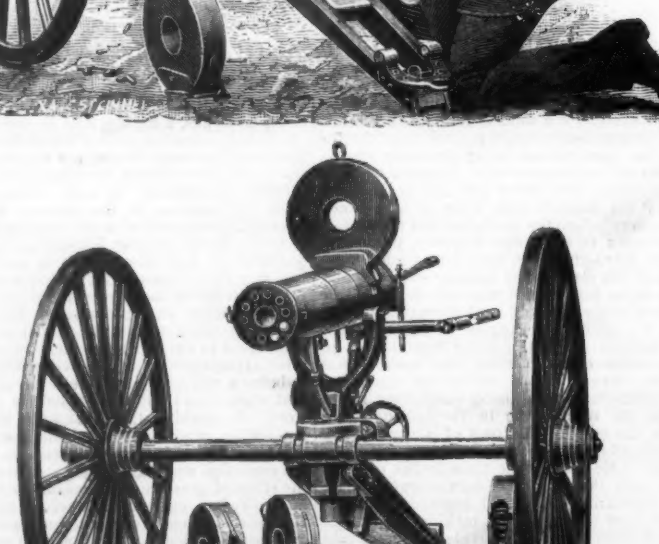
In 1882 Messrs. Thornycroft were building at Chiswick twenty second class torpedo boats for the Admiralty, and they were commissioned by their lordships to fit one of them with a Ruthven propeller in competition with the screw. As the machinery was necessarily heavier, the hydraulic boat was given a little extra length. The dimensions of the screw boats were: length 63 feet, beam 7 feet 6 inches, draught 3 feet 8½ inches, displacement 12·89 tons. In the hydraulic boat the length was increased to 66 feet 4 inches, the beam was 7 feet 6 inches, draught 2 feet 6 inches, and displacement 14·4 tons. The engines, which were compound and surface condensing, had cylinders 8½ and 14½ inches in diameter, with 12 inches length of stroke. They drove a turbine 2 feet 6 inches in diameter at 428 revolutions per minute. The inlet to the pump was at the bottom of the vessel about amidships, and the discharges, 9 inches in diameter, were at the sides just above the water. In all previous hydraulic boats the water had been taken in through a hole in the bottom, in such a way that all its velocity relative to the ship was destroyed before it entered the pump. This velocity had to be restored by the pump, which involved a large waste of power. In the Thornycroft boat the bottom had been formed in such a manner that a large hole was presented to the water at right angles to the keel. The water flowed with unchecked velocity through the pump, and if the vessel was towed along the water was scooped up, flowed of its own accord through the pump, and fell out at the nozzles. The nozzles could be worked from the conning tower, and made to discharge the water ahead, astern, or athwartships, thus driving the boat in either direction or stopping her. On trial the pump discharged 1 ton of water per second, at a velocity of 37 feet 3 inches per second. The horse power developed by the engines was 167. The speed obtained by the boat was 12·6 knots per hour. The engines in the screw boat were considerably lighter. The cylinders were 8¼ inches and 13½ inches in diameter, with 8 inches length of stroke. They developed 170 indicated horse power with 636 revolutions. The speed obtained was 17·3 knots per hour. The method adopted for measuring the quantity of water discharged from the nozzles in the hydraulic boat was considerably more accurate than any hitherto employed. On the Waterwitch very imperfect measurements of the velocity of discharge were taken with a patent log placed in the jet. Measurements were made by the author on the new boat by a thin plate $1\frac{5}{16}$ inches square, attached to the end of the lever, and placed in the jet just where it left the nozzle. The pressure on the plate was recorded by a dynamometer. The apparatus was so arranged that the pressure could be measured at every part of the jet, and not in the center only. The pressure varied greatly in different parts of the jet, the mean being nine-tenths of the pressure in the center. From this the velocity of the water was estimated, and also the quantity discharged.

The efficiency of the jet was found to be 0·71, and of the pump 0·46. In the Waterwitch the efficiency of the jet was 0·35, and of the pump 0·47. In the Swedish hydraulic boat the efficiency of the jet was 0·5, and of the pump 0·55. The total efficiency or ratio of useful work in the jet to the actual work expended in producing it, was—in the Waterwitch, 0·18; in the Swedish boat, 0·214; and in the Thornycroft boat, 0·254. The displacement coefficients at the maximum speeds were, in the Thornycroft screw boat, 169; in the Thornycroft hydraulic boat, 72. The only fair comparison, however, between these two boats was at the same speed of 12·6 knots; the coefficient of the screw was then 140—still nearly double that of the other boat. It must also be remembered that no comparison could fairly be drawn between the coefficients of the Thornycroft hydraulic boat at 12·6 knots and the coefficient of the Waterwitch at 9·3 knots, which was 116. The speed of 9·3 knots was an easy one for a vessel 162 feet long, while 12·6 knots was a speed difficult of attainment by a boat only 66 feet long. If the latter had been designed to run at 8½ knots, its most economical speed, the coefficient would have been 140 against the 116 of the Waterwitch.

In conclusion, it was worthy of note that one of the greatest obstacles to the success of the jet propeller, namely, the loss of energy of the water entering the propeller, had been overcome. It had been clearly foreseen by Mr. Thornycroft; and by adapting the bottom of the boat to meet it in the manner described, the efficiency of the jet had been raised from 0·5 to 0·71. Unfortunately, this obstacle did not stand alone. What efficiency it was possible to get with a centrifugal pump delivering 1 ton of water per second, with a lift of 21½ feet and of limited weight and dimensions, the author could not say; 46 per cent. seemed very low; had it reached 70 per cent., the total efficiency would have been 0·38 and the speed upward of 15 knots. Perhaps this amount of success might yet be achieved for the hydraulic propeller, but it was not likely to be exceeded. The case at present stood somewhat thus: In the screw boat the efficiencies were, engine, 0·77; screw propeller, 0·65; total, 0·5. In the hydraulic boat, engine, 0·77; jet propeller, 0·71; pump, 0·46; total, 0·254. The jet, as a propeller, might be taken as a little better than a screw, but the loss in the pump was a dead loss, and represented about half the power. In other words, before a hydraulic propelled boat could be made to compare favorably with one driven by a screw, the pump producing the jet must work without loss.

THE GATLING GUN.

THE latest forms of Gatling gun, illustrated by the views, have six, eight, and ten barrels, each being provided with its corrresponding lock. The barrels and locks revolve together inside an outer stationary case, but in addition to this the locks have an independent forward and backward motion. The former places the cartridges in the chambers of the barrels and closes the breech at each discharge, while the latter extracts the empty cartridge case after firing. The cartridges are supplied to the gun from magazines consisting of a circular drum of a width slightly greater than the length of the cartridge. On the two circular plates which form the ends of the drum, are spiral grooves running from the center to the outer edge, by which the ends of the cartridges are supported and guided in and out of the magazine, Fig. 7. In the center of the magazine between these grooved plates, are two other circular plates which revolve round the center shaft; they have a number of slots radiating from the center, and are connected near the outer edge by pins (Fig. 8). These two plates, when caused to revolve, force



THE GATLING GUN.

the cartridges along the grooves in the end plates out of the magazine into the receiver of the gun and in front of the locks. The center plates of the magazine are revolved by projections on the receiver, which engage with the pins that connect the center plates, in the form of gear. The magazine is held in its place over the receiver by flanges on each side of the hopper, with two undercut slots in which two projections on the magazine fit, so as to lock it in its place. The slots are of unequal size, so that the magazine cannot be wrongly inserted. On the left hand side of the hopper are two wedge-shaped points that are let down into the receiver and eject the empty shell from the receiver when it has been extracted from the chambers by the backward motion of the lock. The extractor is so formed that its hook remains always in front of the cartridge head, and is rendered stronger by being made double its former width circumferentially. It has no spring, and does not lift the lock by springing over the cartridge head. The cartridge is therefore always struck centrally, instead of at the side. The extractor is so arranged that after each discharge it holds back the firing pin so that its point does not project in front of the lock face until released by the cocking ring, making it impossible for a premature explosion of the cartridge to take place by the lock during its forward motion coming in contact with the cartridge heads. In firing at high elevations the cartridges are prevented from sliding back into the mechanism through the orifice in the front lock flange, either when the locks are in or out of the gun, by the openings being flanged and the lock being made to correspond. The gun has been fired in a vertical position with as much ease and certainty as when horizontal. The rear portion barrels in the gun; when at the rear it fires at each turn of the crank as many shots as there are barrels in the gun. The feed magazines hold from 65 to 104 cartridges each, and weigh from 10 lb. to 24½ lb. when full of cartridges. The musket-caliber guns weigh from 100 lb. to 237 lb. each, according to the number and length of the barrels.

Fig. 1 is a side elevation of the gun; Fig. 2 is a longitudinal section through the axis; Fig. 3 an end view, and Figs. 4, 5, and 6 details of the bolts and extractors. The outer case, *a*, incloses the group of barrels, *d*, which are spaced around the central axis, *b*. At the rear a worm, b^1, is fixed on it. This is rotated by means of the wormwheel, c^1, which is operated by a crank-handle shown in the general view. The receiver for the cartridge is shown at *c*, and *f* is a chamber in one piece with it, into which the sliding bolts, *g g*, are drawn back. These bolts are actuated by cams formed on the ring, *h*, placed within the casing, *a*. This ring is stationery, but the barrels, *d*, the receiver, *e*, and the cylinders, *f*, are carried round together by the crank. The magazine is placed on the casing over the opening in the receiver, being held in place by a spring catch k^1. Figs. 7, 8, 9, and 10 are views of the magazine in place and its relative position to the receiver and the mechanism of the gun. The cartridges descend from the magazine and hopper into the receiver, and the projections, e^1, upon this latter serve to give motion to the propeller of the feeder; the motion of the cartridge till it reaches its proper compartment is controlled by inclines, corresponding with the channels in which the cartridges are guided within the feeder. The spiral ribs on the faces of the feeding drums are shown at l^3, and l^4 are radial slots formed in the side plates of the propeller; in these the bodies of the cartridges lie. The teeth, l^5, on the propeller gear into the projection, e^1, of the receiver, the result being that the cartridges are brought forward at the proper moment. The magazine is charged from an opening in the side, as shown.

ILLUMINATING GAS FROM SAWDUST.

By George Walker.

PERHAPS a short account of the experiments which I have been making here (at Deseronto, Ontario) in manufacturing illuminating gas from sawdust may interest your readers. As sawdust has not, I believe been heretofore used to any great practical extent as a gas producer, a few words regarding its adaptability to such purpose may not be out of place.

The ordinary text-books on gas making and chemistry state that wood is a poor material for the gas maker's purpose, as compared with coal, on account of the small percentage of contained carbon; but this would seem to be controverted by a presentation of the following facts:

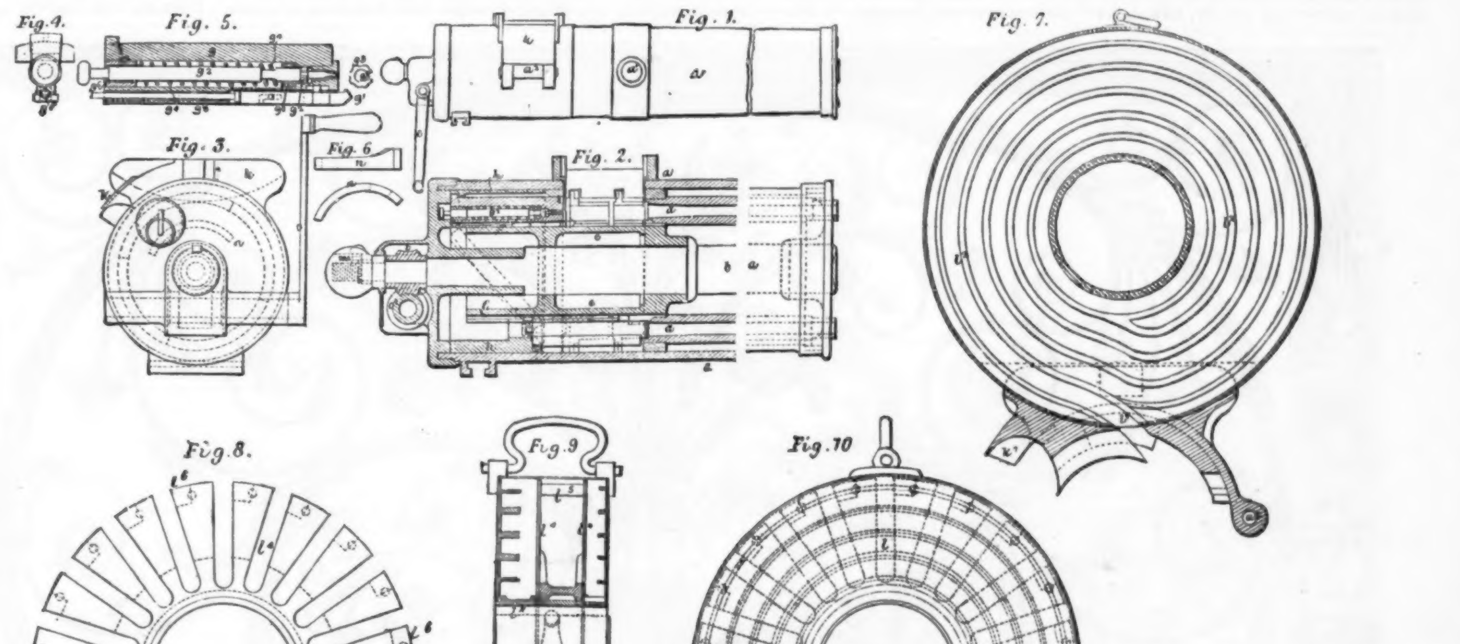
When ordinary bituminous gas coal containing 75 per cent. of carbon is distilled in retorts, about 65 per cent. of the carbon is retained in the carbonizing vessels in the shape of coke, leaving but 10 per cent. available for enriching the resultant gases. Thoroughly dried wood, containing 50 per cent. of carbon, when distilled under similar conditions, leaves 20 per cent. of its carbon in the vessels in the shape of charcoal, allowing 30 per cent. available for the production of gas—or three times the amount obtainable for the purpose in the case of coal.

A comparison in the relative amounts of volatile matters produced from coal and wood shows a still larger difference in favor of the latter. One hundred pounds of coal, producing 65 pounds of coke, leaves 35 pounds volatile matter available for gas making, whereas 100 pounds of dry wood, producing 20 pounds charcoal, leaves 80 pounds volatile matter applicable to a similar use; and, in the case of wood, especially that of a resinous nature, the total quantity of tarry and oily matters, from whence the illuminating power of the gas is largely derived, is much greater than is the case with coal.

On account of the fine state of division in which the wood exists in the form of sawdust, the processes of screening and drying it, preparatory to its use in carbonization, may all be performed by machinery; and it has also the great advantage, as compared with coal, of being capable of continuous distillation, the sawdust being fed into the retorts, and discharged therefrom automatically—and this will be noted as involving a great saving in labor.

Even with the crude experimental apparatus I am using at Deseronto, one man and a boy can produce, from two tons of dry sawdust, in 24 hours, using about one cord of soft wood for fuel, 20,000 cubic feet of gas, and with which this town is now lighted.

The apparatus used is a modification of the old "Halliday" process of distilling sawdust for the production of acetic acid, tar, etc. The retorts are of cast iron, cylindrical in shape, and are provided with a cast iron conveyer, in the form of an Archimedean screw, which conveys the sawdust gradually through the retorts, the heat from the furnace carbonizing it during its passage. The sawdust is supplied to the retorts from an iron hopper placed above and in front of the vessels, and furnished with a vertical shaft and screw conveyer, working in an iron tube connecting the hopper with the retort, by means of which the sawdust is conveyed to the proper receptacles. The mass of sawdust in the hopper and the pipes connecting it with the retorts, as well as the back pressure of the vapor and gas from the in-



THE GATLING GUN.

of the lock is supported by a T way at the center, instead of at the bottom, in order to prevent all possibility of jamming by dust or sand. The gun is mounted on trunnions 2 in. below the center, and is elevated and depressed by means of a circular elevating arc connected at both extremities with the gun, and actuated by gearing so arranged that elevation and depression are indicated in degrees and minutes. A horizontal limb for direction is graduated in the same way. Both kinds of gear are so arranged that they can be instantly thrown out to allow the gun to be moved rapidly in all directions by means of a long handspike. The automatic oscillator is dispensed with, the effect being produced by hand movement of the handspike. An adjustment of the lateral training is obtained by means of stops on the turntable of the carriage, which can be set to any required number of degrees. The adjustment of the vertical oscillation is obtained by means of stops in the elevating arc, which can be set to any number of degrees. The gun can be elevated to 74 deg. and depressed to 78 deg. It is provided with two sights, one on each side. A device is added to serve the purpose of throwing the cocking ring out of action at will, and to prevent the cocking of the firing pins. This is of advantage during drill, and allows firing motion to take place without snapping, and thereby injuring the firing pins. The barrels are locked into the rear flange plate instead of being screwed as heretofore. In case of accident to any lock or barrel, the lock can be instantly removed and the firing continued with the remaining locks.

The gun can be fired with the crank either at the rear or side. When at the side, the gun fires at each turn of the crank about one-half the number of shots to the number of

We shall take an early opportunity of referring to the results obtained at several official trials with this gun, and in which remarkable efficiency has been shown. Experiment has demonstrated that the improved feed has not only greatly increased the direct fire, but is of value in enabling the gun to deliver high angle or mortar fire, so as to drop the balls on men behind entrenched positions at distances of from 200 to 3.500 yards. Experiments with the gun have proved that bullets so discharged come down nearly perpendicularly, and with force sufficient to penetrate from 2 in. to 5 in. of timber. With this new feed there is no chance of the cartridge jamming, even when the gun is used by inexperienced men. The perspective views which we publish opposite give a good idea of the gun and its mode of working, and the upper one illustrates the elevation at which it can be fired.—*Engineering*.

CLEANING MIRRORS.—The best way to clean mirrors, the glass of pictures, etc., is to take a soft sponge, wash it well in clean water, and squeeze it as dry as possible; dip it in some spirits of wine, and rub over the glass, then have some powder blue tied up in a rag, dust it over your glass, and rub it lightly and quickly with a soft cloth; afterward finish with a silk handkerchief.

terior of the carbonizing vessels, prevents air from entering. On the arrival of the carbonized sawdust at the rear end of the retort it drops, through a pipe, into an air-tight iron tube or charcoal-main, placed at right angles with the retorts and equipped with a screw-conveyer, by means of which it is carried to an opening in the conveyer-tube furnished with a valve connecting it to a sheet-iron air-tight car, into which the charcoal is finally delivered.

The vapors and gases evolved from the carbonizing sawdust ascend through an iron tube, extending upward from the rear end of the retorts, and then pass on to the usual condenser, scrubber, and purifier.

When thoroughly dry sawdust is used, and the apparatus is properly constructed, so that air can be entirely excluded, and, at the same time, proper temperatures maintained, a gas is obtained having an illuminating power of from 12 to 15 candles. In the case of yellow pine sawdust, or that resulting from woods containing like percentages of resin, the candle power of the evolved product is considerably higher.

The carbonized sawdust, or charcoal residue left after distillation, has been found satisfactory for gunpowder making, and is also available for a variety of other useful purposes. There is also evolved a quantity of tar, acetic acid, and methyl-alcohol, which, when obtained in sufficient quantities, may be purified and sold. The tar has the same general composition as coal tar, and a similar range of products may be got from it. As sawdust gas contains no sulphur, and but very little ammonia, its purification is simpler than that of coal gas—the only impurities to be removed consisting of tarry matters and carbonic acid. The lime remaining in the purifiers, after the passage of the gas, has none of the offensive smell so characteristic of the fouled lime of the coal gas purifier, although the purified sawdust gas product has a distinct odor, by means of which leaks are readily detected. —*Amer. Gas Light Jour.*

THE UNION OF BODIES BY PRESSURE.

It has been known for some time that two pieces of ice, when pressed together, provided their temperature is near their fusing point, unite and form one homogeneous mass. Nor is this the only case of the kind known to us. Powdered sodium nitrate, perfectly dry and pure, when placed in a stoppered bottle and allowed to stand a long time, becomes a solid block. This block, it is true, can be broken very easily. But suppose the particles could by some means be brought more closely together, would it not follow that the union would be more perfect? And provided the particles could be brought within the range of molecular action, would not the result be the same as if there had been fusion of the mass? Gases are liquefied by causing their molecules to come within the range of each other's action. From this it would seem naturally to follow that substances possessing an affinity for each other could be made to unite and form a *chemical compound* by the same process as that used in the liquefaction of gases.

Led by this kind of reasoning, W. Spring, in 1880, was induced to try the effect of pressure on a large number of bodies. He subjected various substances to great pressure, and announced the result of his experiments to the Royal Academy of Belgium.*

The apparatus used in effecting the pressure consisted of a stout lever moving on a horizontal axis. At the end of this lever heavy weights could be placed, and close to the axis there was a piston moving airtight in a steel cylinder. By the use of various weights at the extremity of the lever a pressure of 10,000 atmospheres was easily produced.

Filings of the various metals were placed in the cylinder and a pressure applied, increasing gradually until the desired effect was produced. In this way blocks of lead, bismuth, tin, zinc, aluminum, copper, antimony, and platinum were obtained, that seemed to be homogeneous throughout. They had the specific gravity of ordinary fused metals; could be filed, sawed, and hammered, and had all the other properties of homogeneous metals. Under the microscope there was no evidence of granular structure. This result, however, was not produced by one application of the pressure. The block obtained after the first application was filed and the filings subjected again to increased pressure, until no evidence of pores could be detected under the microscope. Lead united under a pressure of 2,000 atmospheres, bismuth at 6,000, zinc at 5,000, and copper at 6,000. In no case was the temperature allowed to rise above 130°. At this temperature it was found that zinc united a little more readily than at a lower one. In all cases the block obtained was identical in appearance with that obtained by fusion. The bismuth, when struck, broke with a crystalline fracture, and possessed in common with the blocks of the other metals a highly metallic luster. The ease with which the metals united seemed to be inversely proportional to their hardness.

A very interesting fact, noted in connection with lead especially, was its "flowing." In relation to this Spring says:* "Under a pressure of 5,000 atmospheres, lead no longer resists the piston of the apparatus. It seemed *as if a liquid* were in all the cracks of the apparatus, and the piston was pressed to the bottom of the cylinder. When the apparatus was opened, thin coatings of the lead were found everywhere, which had the appearance of those obtained by plating."

When prismatic or amorphous sulphur was subjected to a pressure of 5,000–6,000 atmospheres, at the temperature 13°, an opaque block of rhombic sulphur was obtained, which was harder than that obtained by fusion. Its specific gravity was 2·0156, while that of the prismatic variety is 1·96. Its fusing point was 115°, that of ordinary rhombic sulphur being from 111° to 114°, and that of plastic sulphur 120°.

Amorphous phosphorus gave evidence of transformation into the crystalline variety.

Precipitated zinc sulphide under 5,000 atmospheres gave a very hard, compact mass, whose exterior had a gray metallic luster; the interior on the contrary appeared to be composed of a mass of crystal fragments, perfectly transparent, and reminded one of blende. The sulphides of lead and arsenic were obtained, with the properties of the natural minerals to a greater or less extent. Carbon in the form of graphite united under a pressure of 5,500 atmospheres, whereas that obtained by heating sugar gave not the slightest indication of union, but appeared to possess "great elasticity."

Copper filings and coarsely pulverized sulphur mixed together and subjected to 5,000 atmospheres pressure, *combined chemically*, and formed a black crystalline mass of cuprous sulphide (chalcocite). An excess of sulphur had been used, and this excess could be detected with the microscope, disseminated through the mass of cuprous sulphide formed.

A coarse mixture of mercuric chloride and copper filings was put under 5 000 atmospheres. There was complete change between the copper and the mercury. The copper had formed cuprous chloride with all the chlorine, and in place of the particles of copper little drops of mercury could be seen.

Dry potassium iodide and dry mercuric chloride, which gave no reaction under ordinary pressure, formed a red block of iodide of mercury and potassium chloride when subjected to 2,000 atmospheres.

In every case (except one†) tried with success, the product obtained had a smaller volume and a greater specific gravity than those of the substances used. Every attempt made to obtain a solid product of less specific gravity than the mean of the specific gravities of the substances used, failed. In general it appears that "the substance takes the condition corresponding to the volume to which the substances used are compressed."

In order to test further the correctness of this law, a mixture of bismuth, cadmium, and tin, in proportions to form Wood's metal, was taken and subjected to 7,500 atmospheres pressure at the ordinary temperature. A solid block was obtained. This was filed and resubjected to the same pressure. The alloy formed fused at 70°. Lead, bismuth, and tin were taken in proportions to form Rose's metal. The resulting block melted in boiling water.*

Besides the substances mentioned, Spring claims to have succeeded in producing the sulphides† and arsenides‡ of many of the metals, and to have produced them with all the properties of the natural occurring substances, especially as regards their crystalline structure.

Within the past year the accuracy of Spring's observations has been called into question by Friedel and Jannetaz of the French Chemical Society.

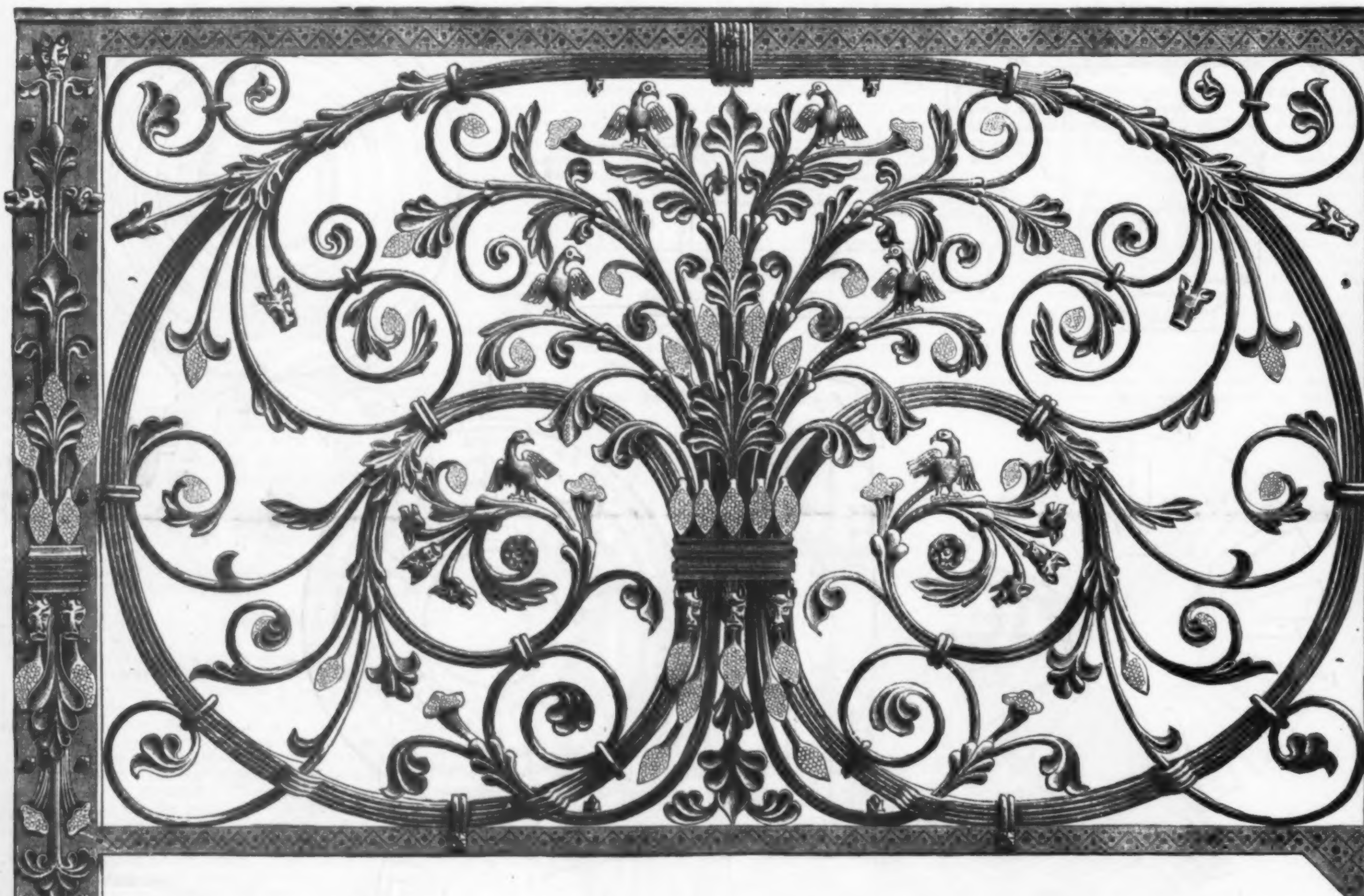
These gentlemen considered the question of so much importance as to warrant further study, and a repetition of Spring's experiments. Friedel§ states that on subjecting the various bodies to 10,000 atmospheres pressure he failed in every case to get complete union. Jannetaz,‖ working with Messrs. Neel and Clermont, subjected antimony, bismuth, tin, zinc, copper, and iron to pressure, and obtained solid blocks, apparently homogeneous. The bismuth seemed to be more crystalline than the others, but was in reality only schistose in its structure. Bismuth, lead, and tin in proportions to form Newton's metal exhibited no indications of union.

Lead chloride formed a solid crystalline block, which probably owed its crystalline structure to the fact that the powder used was crystalline.

In compressing mercurous iodide a little escaped, and a small quantity of mercuric iodide was formed.

Powdered sulphur was mixed with zinc, iron, copper, and lead filings respectively, in proportions to form blende, chalcocite, ferrous sulphide, and galena. Pressure was applied, and the blocks formed were examined very carefully. They presented the general appearance of the substances to which their compositions corresponded. They were translucent at the edges, and appeared to be crystalline. It was very difficult, however, to decide whether they were really crystalline or not, as under the microscope the crystalline powder used in the production of the blocks would interfere with the determination of the crystalline properties of the product.

On examination of their conduct toward heat, it was found that in the solid block, heat was propagated less easily in the direction of the pressure than perpendicularly to it. This has been shown to be a property peculiar to all bodies possessing a schistose structure. Now, it is known that pressure produces this kind of structure, and Jannetaz claims that this is what has taken place in all the cases mentioned above. When the powdered blocks were treated with carbon bisulphide, the sulphur was dissolved and the particles of metal were left. In all cases, however, small quantities of the sulphides were formed, as was determined by grinding the product obtained with acid potassium sulphate, when a slight evolution of hydrogen sulphide was noticed.



PANEL FROM THE COMMUNION RAILING IN THE CATHEDRAL AT VERDUN, WROUGHT FROM ONE PIECE BY A. G. MOREAU, PARIS.

* Bulletin de l'Academie de Belgique, 2 serie, 45, 746; 49, 333. Ann. de Chim. et de Phys., 5 serie, 22, 170.

* Bull. de l'Acad. Belg., 3 ser. 49, 323; Ann. de Chim. et de Phys., 5 ser. 2, 170.

† A mixture of sodium carbonate and arsenic pentoxide gave off carbon dioxide and formed sodium arsenate.

* Berichte der deutschen chemischen Gesellschaft, 15, 595.

† Berichte der deutschen chemischen Gesellschaft, 15, 990, and Bull. de l'Acad. de Belg., 3 ser. 5, 492.

‡ Berichte, etc., 15, 324; Bull. de l'Acad. de Belg. 5, 229.

§ Bull. de la Societe chimique de Paris, 39, 626.

‖ Ibid. 40, 51.

This is claimed as probably due to the heat produced by the pressure, and takes place more readily along the walls of the cylinder than in the interior of the mass. An incident is mentioned in this connection which shows that perhaps the heat produced by these enormous pressures is much greater than is generally supposed.

On subjecting a piece of bell-metal to a pressure of some seven or eight thousand atmospheres, the block burst and pieces flew past the operators and fell some distance off. On picking them up, they were found to be covered with a coating similar to that found on meteorites. This may have been due, however, to the "flowing" noted in connection with Spring's experiments.

Up to the present time Spring has not replied to the statements of Friedel and Jannetaz, so that it is impossible to decide positively as to the value of his results. Before attempting to explain or make use of them, we must wait until he has had an opportunity of repeating his experiments under conditions that preclude any possibility of error either in his methods or in the interpretation of his results. If he succeeds in maintaining his present position, there will be offered to us a ready explanation of many geological phenomena, among them the crystallization of minerals at considerable depths under the surface of the earth.—*W. S. B., Am. Chem. Jour.*

THE ELASTICITY OF SILK.

That silk is the strongest and one of the most elastic textile fabrics in use is a matter which is not so generally known among manufacturers as one would suppose. It is not long since we noticed in a book on the weaving of woolen goods, a remark of the author, stating that wool held the foremost place in this respect. In this case evidently a confusion of ideas had taken place, the author in question having confounded a woolen thread with wool as a fiber. With the exception of silk all textile fabrics are of a limited length, and to form them into yarn they must be twisted together. To do this uniformly and evenly constitutes the skill of the spinner, and in doing this his object is to lay the different fibers together gradually, so that each overlaps its neighbors to a given and regular extent: irregularity in this respect forms unevenness. Now, with short fibers twisted together in this way it is possible to form a moderately elastic thread from material which has comparatively little elasticity. If, however, we employ a fiber which has an inherent tenacity of its own, the degree of elasticity of the twisted yarn is naturally increased. In comparing the degree of elasticity of different textile fibers we must therefore take the fibers in their raw state before they have undergone any kind of manipulation in manufacturing. If, then, we take the hair of a sheep of a given length and a fiber of raw unwashed silk of the same length, we shall find that the latter has a much greater tenacity than the former. Experiments have shown that a fiber of raw silk can be elongated from 15 to 20 per cent of its length, and come back to its original length within certain limits of stretching. This great elasticity is based to a considerable extent upon its construction. It consists of one uniform substance, is of an enormous length compared with all other textile fibers, often measuring several hundred yards, and lastly, is of a uniform thickness, resembling in this respect a metal wire. Correctly speaking, this thickness is larger at one end of the fiber than at the other, but the diminution is so gradual that we may leave it unnoticed in the present instance. This capability of silk of returning into its original dimensions of length when the action of tension has ceased is however, a modified one; nor is this elasticity a uniform one. When only small weights are applied a silk fiber will stretch less than the increase of the weight, a fourfold weight, for instance, only increasing the tension threefold; but when the weight is gradually and considerably increased this proportion is reversed, so that when it is twelve times more than the first weight the tension is twenty-five times more than that produced by a small weight, and it is a remarkable fact that its elongation is the greatest when it is near the breaking point.

Notwithstanding this considerable extension, the fiber shrinks again as soon as the stretching object has been removed, but it does not do it all at once, like, for instance, India-rubber. A certain amount of retraction takes place immediately, but after that it is more slow, perhaps 3 to 5 per cent. of the extension requiring as much as twenty-four hours for its return. After that there is then mostly a permanent elongation, which cannot be brought back except by other means. This permanent elongation also varies with the amount of weight which had been applied to produce the temporary extension. For moderate weights, and approaching the limit of slow expansion, it is inconsiderable. The greater weights produce, however, a more lasting effect, and when silk is elongated about 15 per cent. the permanent lengthening may amount to as much as 7 per cent. We have said before that we have taken these data for raw, unmanipulated silk. If, however, we try the same experiments with washed and boiled silk, from which much or most of the gum has been removed, we shall find that it has lost perhaps as much as half of its elasticity, thus showing that the coherent gum is a great support to the structure of the fiber. We purposely abstain from calling it the strength of the fiber, for in this case strength and tenacity are not the same. In point of fact, the strength of raw silk is about the same as that of an iron wire of the same section; but while this strength is increased by its volume, its elasticity is not increased by the same means, or, in other words, a thread composed of several single ones is stronger than one of the latter, but its degree of elasticity is nearly the same. A matter which considerably affects the elasticity of silk is the degree of moisture contained in it. Dampness, as a rule, makes most textile fibers not only stronger but also more elastic, and with silk it exerts this influence to a considerable degree when a large amount of water is present, and only slightly when the proportion of moisture is small. It has been ascertained by experiments made by Robinet, than whom there is no greater authority on this subject, that when a fiber of silk, in its normal hydrostatic condition, elongated with a certain weight about 20 per cent., the same fiber could be stretched as much as 23 per cent. when thoroughly saturated with water, while after desiccation in a conditioning apparatus its elasticity reduced to 8 per cent. Other substances which affect the elasticity of silk are the dyes and drugs which are put into it by the dyer. Silk, unlike some other textile fabrics, has a power of absorbing many substances, and when they have penetrated its substance they naturally expand it, thus shortening the length of the fiber, and also reducing its elasticity by, so to speak, intervening between its atoms. This latter interference with its structure is of considerable importance in dyeing, and especially in the pernicious process of weighting. The greatest harm is done to silk in this way by certain acids and metallic salts, for by interfering with its natural structure they burn the silk, as it is called, which is nothing else than depriving it of its elasticity, so that sometimes a simple folding is sufficient to break a texture of silk. The dyer and finisher have to rely much upon the elasticity of silk. Many dyes, as we have just mentioned, have a tendency to shorten the fabric, and consequently the length of a hank. The dyer is therefore compelled, with the assistance of proper machines, to stretch it, and to do this to a considerable extent, so as to attain a permanent elongation, a moderate stretching, as we have shown, not giving him the desired results. Inasmuch, however, as highly charged silk losses its elasticity, this stretching becomes sometimes a dangerous process, and may cost the dyer the loss of the whole of the material. In this case the quality of silk to acquire a higher degree of tenacity when charged with water comes to his assistance, and his stretching process is therefore best performed when the silk is very moist. He may also derive advantage from the addition of gelatines and other glutinous substances, in substitution for the gum it has lost through boiling, so as to regain a little of the elasticity which the natural gum imparts to it.—*Textile Manufacturer.*

NOTTINGHAM MECHANICS' INSTITUTE NEW READING ROOM.

The accommodation of the building of this institute has recently been very much increased by the addition of a commodious new reading room, 80 feet by 26 feet; storeroom (of similar area) in basement; kitchen, 36 feet 6 inches by 19 feet 6 inches, and a complete system of water closets, lavatories, and urinals.

The new buildings are erected on a long strip of ground, having a frontage of about 30 feet to Milton Street, on which they abut with a semicircular stone front, covered with a green slated roof, surmounted with an open timber dome. The height available was somewhat limited, owing to the existence of important side lights in the old building. The additions are mainly lighted from above, and Rendel's patent glazing has been exclusively patronized. The chief contracter is Mr. Henry Vickers, and the hot water and sanitary engineers, Messrs. Goddard & Massey, both of Nottingham. The architect is Mr. Sidney R. Stevenson Nottingham.—*The Architect.*

RELICS OF THE SANTA BARBARA INDIANS.

Rev. Stephen Bowers, Ph.D.

Point Concepcion is 259 miles southeast of San Francisco. Here the shore-line of the Pacific trends eastwardly, and for the distance of nearly 100 miles runs nearly due east and west. Parallel with the shore-line and about thirty miles distant is a chain of islands, four in number, the smallest of which is but a few hundred yards wide and five miles long. The largest is twenty-two miles long by about five miles in width. The counties of Santa Barbara and Ventura, including the islands, embrace the territory in which lived what we may denominate the Santa Barbara Indians. Further out in the ocean are other islands once inhabited by Indians, but whether they belong to the Santa Barbara stock is not known.

Our first historical knowledge of these Indians dates back 342 years, or to the year 1543, when Cabrillo discovered this coast. He represents this portion of California as thickly populated with Indians, and somewhere not far from the town where the writer is living and dating this communication, he speaks of a large Indian town called by the natives *Xucu*, but which he named De los Canoas, because of the great number of canoes owned by the Indians at that place. While anchored here two Indians came on board of one of his vessels and pointed out twenty-five Indian towns, the names of which Cabrillo records.

For 100 miles along this coast between Point Concepcion and Point Magu, the writer has examined about one hundred rancherias, or sites of old Indian towns. Back in the mountains and along the streams in the territory above mentioned they are also abundant, while the islands are literally covered with their shell-heaps or kitchen debris.

This genial climate and the abundance of food produced by land and ocean made this a desirable spot for the Indian, who is naturally antagonistic to labor. The sea yielded abundance of fish, mollusks, and water-fowl, while the foothills and mountains contributed much game. In their shell heaps may be found every variety of mollusk now known here, prominent among which were edible clams and the *haliotis*, all of which still exist along the sea-shore. The bones of whales, seals, sea-lions, sharks, black-fish, porpoises, and many other fish are prominent in the old rancherias; also the bones of water-fowl, deer, bears, etc. This section was the Indian paradise of the Pacific coast.

When the Jesuit missions were founded here a century ago, the islands and the mainland teemed with multiplied thousands of Indians, but now none are left to tell the story of their existence. They rapidly faded away before another form of civilization. Most that we can now learn of this race is obtained from their burial places, which were generally located in the midst of the village. They seemed to have had but one method of burial, and that was to draw the knees up against the breast and place the face downward, burying one on top of another.

In some places in a radius of a rod or less the writer has exhumed a hundred skeletons. These were found from one to four feet below the surface, and in some cases, six and even eight feet.

It is most likely that all the earthly effects of the individual were buried with the body, but only the stone, bone, and shell implements and ornaments remain. In some rare instances the writer has discovered ornaments of red-wood, which of all California wood is probably most durable. Coarse cloth has also been found with the skeletons.

After the missions were established the Indians were probably buried in the cemeteries of the priests, and it is not likely that burials have taken place in the rancherias later than seventy years ago.

It is known that the last of the Indians were removed from the channel islands nearly seventy years since, yet thousands of skeletons have been dug up on these islands in a fine state of preservation, while the shells in the rancherias still retain their markings perfectly.

The relics found with the dead often show superior workmanship. Mortars of sandstone were made by dressing the outside to the shape of a cast-iron kettle, such as are used for sugar or soap making, after which the block of stone was excavated, often leaving the sides little more than an inch in thickness in a specimen twenty inches or two feet in diameter.

These mortars varied in size from a few inches to thirty inches in diameter, and were used in triturating acorns, etc., for food. The pestles were made of the same material, and varied in length from five to thirty inches. They were made with much care, gradually sloping from the base to the smaller end, where there was often left a raised bead or knob, and sometimes two or three.

Ollas or cooking vessels were carved out of crystallized talc, and would hold from one to six or eight gallons. They were globular in shape, and again bell or pear shaped, the sides thin and the mouth surrounded with a raised bead or ornamented with chevrons, or both. Some of these were as perrect as if turned in a lathe.

Tortilla stones were made of the same material. They would average about seven or eight inches in length and width, but were in the shape of a keystone, and about one inch in thickness. A hole was drilled in the smaller end for handling them when hot. They were heated in the fire, and the dough being rolled thin was rapidly baked. Some who have eaten tortillas pronounce them very good.

But the most beautiful specimens are those made from serpentine. Cups, bowls, pipes, and many ornaments were made from this mineral. The cups and bowls were from about two to twelve inches in diameter, variously shaped, and sometimes with handles similar to the old-fashioned skillet.

Some of these described a perfect circle, and were finely polished. The pipes were cone-shaped, varying in length from two to twelve inches. A bone mouth-piece was inserted in the smaller end, and it was smoked cigar fashion. The ornaments were various, but usually pendants. Most of the serpentines used contained seams of chrysolite, and when polished were very handsome. Some of the finest arrow-heads and spear-points I have ever seen were found in the burial places.

They were manufactured from white and black chert, jasper, chalcedony, and obsidian. I found one spear-point manufactured from dark brown chert but one inch in width and over twelve inches long, very accurately made in every particular.

Many most delicately finished arrow-heads with double barbs and, indeed, a great variety of shapes have been found on the mainland and on the islands, which were probably used as ornaments in the hair and on different parts of the body. The wearing of them in the hair is referred to by Cabrillo.

In a burial place on the Santa Ynez River I exhumed some two hundred skeletons in a radius of about fifteen feet. With these occurred twenty-eight sandstone mortars holding from about two quarts to more than two bushels; forty-four pestles from a few inches to more than two feet in length, made of sandstone, polished and ornamented. They exhibited a great variety of finish, no two being exactly similar at the smaller end.

There also, occurred twenty ollas manufactured from

steatite or crystallized talc, which were used for cooking vessels. They would hold from one to five or six gallons. This burial place yielded forty-four cups or bowls made principally from serpentine.

I also found twenty-six pipes, which indicated the smoking propensities of this people. Also eight spear-points, twelve arrow-heads, one asphaltum jug, five cement cups made from the vertebræ of large fishes, twenty-four metal knives nearly destroyed by rust, six arrow smoothers, ten tortilla stones. Besides these occurred stone knives and drills, bone whistles, a copper spear, charms, and tubes of stone, and at least a half bushel of beads, wampum, ornaments of shells, bone, and stone, a description of which would require a whole volume.

San Buenaventura, Cal., March 4, 1884.

—*Kansas City Review.*

THE TREASURIES AND ANTIQUITIES OF SALAMIS, CYPRUS.

MAJOR ALEXANDER PALMA DI CESNOLA, F.S.A., the author of "Salaminia,"* enthusiastically describes himself as simply a "digger up" of antiquities, without laying claim to the profession of archæological knowledge, and as he graphically describes the frequently unsuccessful results which followed his enterprises, he explains that no one, save an excavator, can thoroughly understand the feelings experienced during such undertakings. At the moment of expectation the excitement of a digger can only be compared to that of a gambler; but if he has many disappointments, he also has great pleasures and much satisfaction in the progress of his work, which satisfaction Major Di Cesnola experienced in a very fortunate degree during the three years of his explorations at Salamis, due chiefly to his perseverance and discernment, added to his acquaintance with the native character and requisite resources for conducting his operations to a successful issue. The two methods of exploring the antique world are these: digging in the ruins of cities and digging in the tombs of their inhabitants; and these methods are interestingly described in the preface of the admirable volume now before us. When digging in ruins, shafts are sunk near spots bearing indications of palaces, temples, or other large buildings. These shafts are made a few feet apart to varying depths, the depth of each being dependent on the finding of rock or virgin earth. When these substances are reached, there is no hope for researches in these directions; the pits are, therefore, abandoned, and other parts are tried with further pits and cuttings. When the shafts disclosed a foundation or pavement, the working was continued in the direction indicated, till remains of more or less value were discovered. Searching for tombs is conducted in nearly the same manner as among the ruins, the only change in the method of seeking being due to the different construction of the tombs, and this depends upon the people who buried their dead in them, for, of course, the antiquities are in accord with the people to whom they have belonged. In digging for tombs, objects generally found are of gold, so that the expenses incurred are on the whole recovered. The diggers usually worked in small parties of three or four, each gang working under the constant supervision of Major Di Cesnola, who payed the fixed wages of 1s. per day, paying them every Saturday, also for the objects they had found at a rate fixed beforehand by the foreman and workmen together, and during an experience of three years no cheating was noted either among the orthodox or the Mohammedan workers forming the party, while it would be difficult to say which of the two were the most faithful. The result of the labors thus carried on is a very extensive and beautiful collection of Cypriote antiquities and Phœnician art, including several unique specimens of gold and silver ornaments, terracotta, and glasswork, besides a series of 1,600 coins in gold, silver, and bronze of every dynasty which has occupied the island in ancient times, the whole forming the Lawrence-Cesnola collection, which includes about 4,000 relics both in glass and in terracotta, all discovered by the writer of "Salaminia." Dr. Samuel Birch, of the British Museum, has written a comprehensive and extremely interesting introduction to the second edition of this work, giving a comprehensive outline of the history of Cyprus, pointing out the new and important light which these recent discoveries, made in the island, throw on the general progress of art, for they form a connecting link between the Greek and Phœnician or Aryan and Semitic civilizations. That Cyprus received colonists from the three continents of the old world is undoubted. Evidence of the Phœnician and Greek colonists is proved by the remains of these nationalities found on the coast and elsewhere, while the conquest of the island by Egypt and Assyria has been recorded in the annals of those countries, and their acts have left the stamp of their impression on the sculpture of Cyprus. At the time of the eighteenth Egyptian dynasty, fifteen or sixteen centuries before Christ, Cyprus was known to the Egyptians, and had evidently been colonized and inhabited. The Greeks anterior to the time of Homer had peopled portions of the island, and the coast was held by their settlements, the establishment of which has been attributed to the period of the Nostoi, or return of the Greeks from the Trojan War, and cannot be referred to a later date than nine centuries before the Christian era. Contemporaneously or later, the Phœnicians had migrated to Cyprus, and mingled with the Hellenic population. In the seventh century before Christ, Assyrian annals show that Cyprus was held by numerous princes, for as early as B. C. 715 seven kings of Cyprus had sent tribute to Sargon at Babylon, and at a later period ten kings of Cyprus, among whom appears the king of Salamis, propitiated Esarhaddou and Assurbanipal with their tribute. To the Egyptians, Cyprus "was the isle in the middle of the great sea," perhaps the Khaft of the earlier period, and the Masenia of the later age. The arts of Egypt and Assyria had a striking influence upon Phœnician art, and also considerably modified the sculpture of Cyprus. To the later period of Cypriote art belong the sculptures and other objects which were made after the Greek element obtained a stronger hold on civilization. Besides the sculpture, innumerable articles of foreign fabric, opaque glass toilet vases, made at an early period in the furnaces of Phœnicia, and bronze bowls or cups with subjects in relief, like those of Assyria and Etruria, poured into the island by the intercourse kept up with the coasts of Syria and Egypt. These vases, found deposited in the tombs of Egypt, the graves of the Greek isles, and the sepulchral chambers of Etruria, and which are now known to be at least as old as the sixteenth century B.C., have also been found in the necropolis of Salamis, and they are among the most beautiful products of ancient art, and the predecessors of the glass chefs-d'œuvre of Rome and Venice. Some examples thus found were doubtless made at Tyre by Phœnician workmen, and others are Greek, and many belong to the Roman period.

* Salaminia (Cyprus): the History, Treasuries, and Antiquities of Salamis in the Island of Cyprus, by Alexander Palma di Cesnola, F.S.A., with introduction by Dr. Samuel Birch, F.S.A. Second Edition. London: Whiting and Co., Lim., 30 and 32 Sardinia Street, Lincoln's Inn-fields.—*Building News.*

SUBMARINE EXPLORATIONS.*

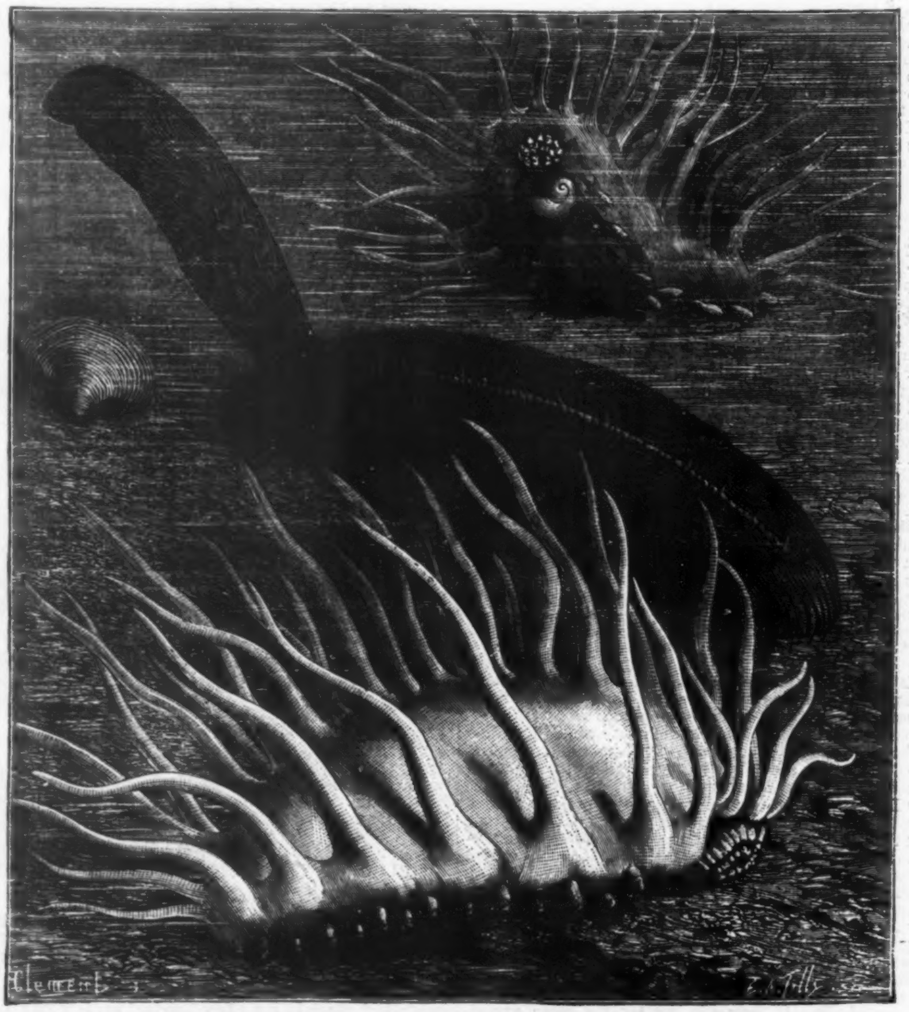
THE mollusks collected during the cruises of the Travailleur and Talisman consitute a numerous series interesting to study. Some were taken near the surface, and others at depths increasing to more than five thousand meters. The surface species were nearly all of them well known, and we shall not stop to describe them. The only ones that merit notice are those that live in the Sargasso Sea, amid the algæ floating in the ocean. These are species deprived of shell (*Scyllea pelagica*), and whose body, for protective purposes, possesses exactly the color of the vegetation by which they are surrounded.

The most productive and interesting of the dredgings made during the cruise of the Travailleur were those that were made in the Gulf of Lyons at depths of from 445 to 1,685 meters. These gave more than sixty species, several of which, found in a fossil state in the Pliocene deposits of Italy, would not have been supposed to exist at the present day. Some of these species were afterward found again by the Travailleur and the Talisman in the Gulf of Gascony, and off the coasts of Portugal, Morocco, and Senegal. *Terebratella septata, Leada Messaniensis, Limopsis aurita, L. Minuta, Pleurotoma Loprestiana, Columbella costulata, Turbo romettensis*, etc., are some of the Pliocene forms that still survive in our present seas. As regards the geographical distribution of the deep-sea species of the Mediterranean, the explorations of the Travailleur and Talisman have brought to light a fact of extreme importance. The mollusks that live in the abysses of the explored portion of the Mediterranean are all, without exception, found in the ocean. Consequently, it appears to be well demonstrated that the first of these waters has received its deep sea fauna from the second after the geological period that closed its communication with the Indian Ocean.

During the course of the Talisman's cruise the questions to be solved regarding mollusks were the following: (1) What is the composition of the fauna that inhabits great deaths in intertropical spaces? (2) Are the animals that compose such fauna peculiar to the region where they reside, or, are they representatives of species that have been found in the Arctic seas? The extent of the voyage made by the Talisman from north to south—from Rochefort to Senegal—has permitted these questions to be answered. Mr. Fischer, who devoted himself specially to a study of the mollusks, found an extreme difference between the surface and deep fauna of intertropical Africa. The genera are no longer the same, their reciprocal associations have no relation, and, if the remains of these faunas were fossilized, it might be thought that they corresponded to two distinct epochs, or that they represented the population of two non-communicating seas. There is no need of pointing out the importance of this latter fact, since it is evident that in geological studies, in which an examination of the molluscous fauna is much relied upon for determining the age of marine strata, the absolute differentiation, in the same region and same sea, of surface and deep sea faunas will always hereafter have to be taken into great consideration.

As to the constitution of the molluscous fauna of the abysses, our explorations have shown that, alongside of species peculiar to the regions and depths at which they were collected, there exist others whose great area of geographical distribution extends as far as to the Arctic seas. Thus, *Fusus berniciensis* exists at Denmark, to the north of Russia, off the Shetland Isles, in the Gulf of Gascony, and off the entire coast of Morocco and the Sahara. *Scaphander punctostriatus* extends from Finmark, from the Lofoten Islands, and from the north of America as far as to the Gulf of Gascony, and afterward follows the coasts of Portugal and Africa as far as to Senegal. We might still further multiply such examples of the immense distribution of certain species of mollusks. All those species of the cold seas whose existence in the tropics is now revealed to us give rise, as regards the depth at which they live, to observations of the same nature as those that we have already made upon those crustaceans that likewise extend from Arctic to tropical seas. The limits of depth increase in measure as we advance toward the equator. Thus, *Fusus berniciensis*, mentioned above, lives off Denmark at depths of between 90 and 150 meters, and off Cape Bojador at 1,918. So *Scaphander punctostriatus*, found at between 36 and 450 meters off Scandinavia, descends to 2,200 off Cape Ghir, and *Malletia obtusa*, which appears off Norway at a depth of 365 meters, descends to 3,200 in the vicinity of Senegal.

The shells of deep sea mollusks, as regards form, exhibit nothing peculiar, and, as the animals to which they belong are always of small size, they are not very large. Their walls, which are thin and fragile, exhibit in certain instances very remarkable iridescent colors, especially in *Ziziphinus triporcatus* and *Trochus gloria-maris*. But it seems that when we reach depths below from 1,500 to 2,210 meters brilliant colors give way to dead white. A remarkable example of this was seen in *Neæra lucifuga*, which was taken at a depth of 3,005 meters.



DEEP-SEA HOLOTHURIANS.

The mode of life of deep sea mollusks is very varied. Certain of these animals, such as *Fusus berniciensis, Ziziphinus triporcatus*, and *Trochus gloria-maris*, wander over the ocean bottom, while others, such as *Dentalium ergasticum* (whose shell is like a large horn), lie partially buried in the mud. So too *Modiola lutea* anchors itself in the mud by means of an enormous byssus, while the mussels of our shores, whose external form is quite similar, make use of the same apparatus to fix themselves to rocks. Finally, other mollusks, such as *Waldheimia, Terebratula, Terebratella*, and *Rhynchonella*, which are very abundant in a fossil state in certain strata, live fixed to fragments of rocks or upon corals.

The absence of light at great depths results in causing the disappearance of the eyes in certain mollusks, just at it does in some crustaceans. Thus, *Fusus abyssorum*, which we took at a depth of 5,000 meters, and *Pecten fragilis* at 3,000 meters, possessed no organs of sight.

After mollusks come the echinoderms under a multitude of forms. Some of these animals, such as the Holothurians, were found in abundance at depths of from 4,000 to 5,000 meters. *Oneirophanta* and *Psychropotes*, shown in the accompanying engraving, were taken at depths, respectively, of 4,787 and 5,000 meters. Holothurians, which generally have an elongated and cylindrical body are vulgarly known as sea-cucumbers. Some species attain a large size. The *Psychropotes* that we took were 70 centimeters in length. The leathery and granular skin of these animals is filled with calcareous corpuscles, and upon its surface there are seen hollow, extensible, usually symmetrical organs that bear suckers at their extremity. The mouth is situated at one

* Continued from page 7011.

end of the body, while near the termination of the intestine that opens at the other extremity of the animal are seen the orifices of the ramified tubes which constitute the respiratory organs. When Holothurians are irritated (when they are seized, for example), they contract and suddenly expel their viscera. But what is most singular, and most inexplicable, is that after a short time the expelled organs are reproduced anew. The forms that we illustrate herewith are very interesting, first, by reason of their special habitat at great depths, and secondly, in that one of them is covered with long tentacles while the other, whose body is nearly smooth, is provided at its extremity with a nearly erect tail.

It would seem as if the life of these animals, at both slight and great depths, must pass in perfect quietude. This, however, it not at all the case, for those species that live near the surface, as well as those that exist at depths of between four and five thousand meters, are annoyed by a host of commensals and parasites. Thus, certain of them are transformed, as Van Beneden says, into a sort of *living hotel*. Some give lodging within their respiratory tubes to certain small fishes with an elongated, eel-like, but compressed body. Others, such as *Holothuria scabra*, of the Philippine Islands, give shelter in their interior to one or several couples of those small crabs called pinothera, or else, as *Holothuria tubulosa*, carry in their intestines those worms that are called *Anoplodium*. But, aside from these commensals, that do not live at the expense of their host, there are others that demand their food from them. In the engraving we show one of these parasites—a mollusk of the genus *Stylifer*—which is clamped, if we may use the expression, to the throat of an *Oneirophanta*, and is sucking from the tissues that it has pierced the nutritive juices that are necessary for its existence.—*La Nature.*

CHRYSANTHEMUM ANEMONES.

MESSRS. VILMORIN'S book, entitled "Les Fleurs de Pleine Terre," consisting, as it does, of carefully drawn up descrip-

FIG. 1.—CHRYSANTHEMUM ANEMONES.

tions of garden flowers and copiously illustrated with small but characteristic woodcuts, is a book of unquestionable utility—a fact made evident, among other things, by the large use that has been made of it by subsequent compilers. The last edition of that work, we are surprised to find, dates as far back as 1870, since which time numerous additions have been made to our hardy plants. In the present supplement

FIG. 2.—POPPY ANEMONES.

the authors have extended their programme, so as to include plants which can be grown out of doors for the greater part of the year, but require the protection of a frame or heated pit during the winter in Northern France, and may be cultivated throughout the whole year in the open ground in the extreme southern and western districts. MM. Vilmorin tells us that a selection has been made so as to exclude plants of inferior merit, of delicate constitution, those which are not yet sufficiently tried, or which are otherwise unsuitable for general cultivation.

It may serve at once to illustrate the nature of the present supplement, and the progress of horticulture, to say that begonias occupy seventeen pages. Chionodoxa finds a place, as also do single dahlias, the so-called double gaillardias, hybrid hellebores, papaver umbrosum, the newer kinds of petunias, phloxes, Primula rosea and other species, China asters, and many others. The descriptions have evidently been drawn up *de visu*, and are not merely paraphrased accounts taken from books, as is the case with so many garden compilations, while as to the illustrations we cannot better indicate their character than by reproducing some of

FIG. 3.—ANEMONE FULGENS.

them—for the privilege of doing which we are indebted to Messrs. Vilmorin.

Fig 1. shows a bunch of the chrysanthemum anemones (A. coronaria var.), in which the outer perianth segments are relatively small, while the stamens and pistils are more or less completely replaced by narrow strap-shaped petaloid segments. The first varieties of this section were, we are told, raised some fifteen years ago by M. Bahuaud Liton, nurseryman of Nantes, and now there are many named varieties of different colors. Fig. 2 represents flowers of the Caen race, called in England poppy anemones (A. coronaria var.), a robust strain similar to the preceding, but in which the outer perianth-segments are large. Anemone fulgens (Fig. 3), the A. hortensis of some writers, is wild in the South of France, and even in the wild state is extremely variable in color. "In addition," say MM. Vilmorin, "to the numerous lilac and reddish-flowered forms often cultivated under the name stellata, there are two others so distinct as by some to be considered as distinct species. One is the peacock anemone, with broad flowers of the richest color, but with a yellow eye; the other is the Pyrenean form of A. fulgens, in which the flower is self-colored of the most brilliant scarlet hue. This variety is rather less tender than that which grows in Provence, and requires less heat to enable it to flower. The first leaves are thrown up from the dark fleshy root-stock in the autumn, and are more or less five-lobed; those produced subsequently in spring are much more

FIG. 4.—DOUBLE-FLOWERED ANEMONE FULGENS.

divided, and reduced to linear segments. Growth ceases about the end of June, and the plant goes to rest for six or eight weeks—a period most favorable for division and transplantation. Anemone fulgens is easily reproduced from seed, the seedlings producing flowers of varied hues from white to blood-red, and sometimes with the stamens and pistils replaced by petaloid segments, as shown in Fig. 4.—*The Gardener's Chronicle.*

A NEW SPIRÆA.

(*S. astilboides.*)

So seldom does a Spiræa occur among the multitudinous new plants that appear every year, that this one is of special interest, especially as it belongs to the Aruncus or Goat's beard section, and is said to be hardy. It grows from 2 feet to 3 feet high and forms a dense symmetrical bush. At

FLOWER BRANCH OF SPIRÆA ASTILBOIDES, AND PLANT SHOWING HABIT OF GROWTH.

flowering time the branches are furnished with myriads of white blossoms in plumy clusters, as shown in the annexed illustration. It may be forced into flower as early as March; hence it is an invaluable plant for pot culture for conservatories. It has been introduced by Mr. Bull, of Chelsea, from whose new plant catalogue the accompanying woodcut is taken. It has been certificated both by the Royal Horticultural and Royal Botanic Societies, and whenever it has been exhibited it has been much admired. It will, doubtless, prove to be a plant of the easiest culture, both in pots and in the open ground.—*The Garden.*

REPTILES AND MUSIC.

It has been for a long time said that animals are fond of music. This fact is true, even as regards reptiles, and it is these animals that we shall speak of at present. Tradition will have it that Orpheus had the power of enchanting the most venomous reptiles, and it is said that the Argonauts conquered by power of song the terrible dragon that guarded the golden fleece. Pliny and Seneca tell us that the principal power of snake charmers resided in the attractions possessed by music.

In America, when a savage has the talent of whistling agreeably, he can without difficulty approach the iguana and capture this gigantic lizard, whose flesh is said to be so good to eat. Like all other saurians, the iguana listens to melody with such attention that it forgets to look out for its own preservation. This proves that melomania may sometimes prove fatal.

Father Labat went with a negro on one occasion, at Martinique, to hunt this lizard, his companion being armed with a pole provided with a slip noose at its extremity. One of these animals having soon been observed stretched out in the sun upon the branch of a tree, the negro began to whistle to it, whereupon the reptile thrust its head forward as if to discover whence the sound came. Then the negro, slowly approaching, and whistling all the while, began to tickle its sides and neck with the end of the rod. This gave the reptile so much pleasure that it began to roll over and over upon its back and sides, and, at a certain moment, got so far over the branch that the slip noose could be passed around its body, its tail to the side of the basket and following, by the motions of its head and body, those of the musician who was walking and playing. The musician took the serpent from its basket, placed it around his neck, and began to play again, when the reptile remained motionless as if in an ecstasy of pleasure.

The spectacled viper, (*Naia tripudians*), one of the most dreaded species that inhabit India, is tamed by men called *Snokembus*, who, to the sound of the flute, make it go through a sort of dance. This reptile, which is still adored by the Hindoos, comes out of its retreat when it hears the noise of a flageolet or pipe, runs toward the musician, and takes food from the latter's hand.

Dr. Shaw had an opportunity of seeing a large number of serpents that performed with the dervishes in their round dances, the reptiles gliding over the head and arms of the priests, turning around when they turned, and stopping when they did.

According to Captain Percival, the cobra, even when it has just been captured, seems to listen with extreme pleasure to the notes that are rendered by any instrument whatever.

Jugglers put to profit this natural inclination of the snake; and there are some who take the trouble to tame cobras and teach them how to mark time and accompany the airs that they are playing, with a motion of the head. Reptiles that have been charmed assume attitudes that are in harmony with the feeling of the music, be it gay or sad, light or grave.

During my sojourn in the Indies, says Franklin, I saw a cobra de capello captured in my garden. The snake charmer, having a plumed turban upon his head, seated himself before a hole in a hedge of thorny pear trees, and played upon a rude musical instrument made of a gourd. The cobra soon showed his head in order to listen to the wild sounds, its eyes at the same time being attracted by the reflections from a piece of broken glass in front of the gourd instrument. Then, without taking the trouble to extract its venomous fangs, the charmer slipped the serpent into an open basket. The next day the charmer returned, and, placing his basket on the ground, crouched down behind it and began to play his wind instrument. The cover then rose and the snake made its appearance half-coiled, and began to wag

SNAKE-CHARMERS.

One of our most eminent scientists, Mr. Quatrefages, tells us that he long kept in captivity, or rather in quasi-domesticity, one of the prettiest of our French reptiles, the green lizard. "Hearing," says Mr. Quatrefages, "is highly developed in all lacertians; they can hear the noise of a leaf agitated by the wind, or the buzzing of a fly, at a distance of several feet. Further than this, their very fine ear, although provided with an arrangement for re-enforcing sounds, appears capable of distinguishing them. The facts that I know regarding the iguana caused me to make some experiments that were quite curious. When I entered a room where an instrument was being played, having my green lizard with me, the latter immediately became restless and showed its head over the edge of my cravat, and when I placed it upon the floor it ran in the direction whence the sounds came. Among different instruments, the flute and flageolet seemed especially to please it. The noise of cymbals and of the Chinese gong startled it, while it became insensible to that of the bass drum." It will be seen from this that if certain travelers have exaggerated the dilettanteism of reptiles, they have at least not invented everything. Fetis and Dr. Chomet have described the influence that melody exerts upon lizards. If any one whistles at these animals while they are endeavoring to escape, they often stop, and, provided the air is an agreeable one, listen to it with evident pleasure.

Ophidians are none the less sensible than saurians to the charms of music. The naja will rise upright at the sound of the flute, and beat measure in following the time marked by the music. Its head, which is naturally round and long, like that of an eel, then enlarges and flattens like a fan. The ears of the snake are located under the skin, and from this anatomical circumstance one might be led to think that it was a little hard of hearing. Yet in certain cases we find a musical sense developed in this class of reptiles. J. Franklin relates that a gentleman one day having met some children who were teasing a snake of the most harmless kind, took pity on it, saved it from the hands that were maltreating it, and carried it home. There he placed it in a basket suspended from the ceiling of his room by a cord. One evening, while this gentleman was walking backward and forward in his apartment and playing the violin for his own amusement, what was his surprise to see the reptile fixed by his head at the sound of the music, just as the dilettanti do in the balcony of the Italian Opera. From time to time it displayed its hood, or hissed when the charmer held his hand toward it. A companion who stood behind the musician then seized the animal by the tail, but, held in this way, it could do no harm. Without going to India, we may also find jugglers called snake-charmers no farther off than Cairo. These men cause the famous asp of the ancients (now called haje) to move its neck rhythmically to the sound of whistles or small flutes. It is said also that by pressing this snake on the nape they throw it into a stiff and immovable condition, which they call turning it into a rod. It is certain that these jugglers could not handle this serpent with impunity without neutralizing its venom in some way or other. Finally, even the terrible rattlesnake allows itself to be captivated by music. An instance of this is related by Chateaubriand, who states that he saw one of these reptiles charmed by an Onondaga Indian, on the banks of the Genesee River in 1796, by means of a flute.—*Science et Nature.*

WHAT IT IS TO READ MUSIC.*

By Prof. Charles F. Kroeh, of the Stevens Institute of Technology.

It is not as a professional musician that I venture to address this convention, but as a student of educational methods. As such, I hold that education is a fine art, and that any method calculated to spread musical knowledge among the masses is worthy of serious and patient investigation. For this reason, and because I love music, I have passed through a course of the Tonic Sol-fa method, and have followed it up with earnest research, the result of which I purpose to lay before you now.

READING INSTRUMENTAL MUSIC.

It is very difficult to explain to any one totally unacquainted with the subject, what is involved in reading vocal music. It ought to be a process entirely different from that to which players of musical instruments are accustomed when they play by note. Their way is so simple that it needs illustration here only for the purpose of contrast. Suppose we have before us the following measures:

It will be the simplest thing in the world to take a child to the piano and show it where to put its finger to strike the first note. The next one is the same; the third is the nearest black key on the left, and so on, explaining that *down* on the staff means going to the *left* on the key-board, and up means going to the right. Very little explanation is needed to teach what key must be struck for each line and space, and how the signs ♯, ♮, and ♭ enable us to get along with fewer lines and spaces. It is only a question of time and practice to bring about the desired end, namely, that the child will put its finger mechanically upon the key that sounds the note proper to any given line or space. What is true of playing single notes is true of playing chords.

The mind learns to associate the impression upon the eye with the necessary action of the fingers.

All this is done every day without in the least training the ear, or to be more accurate, without any training that is conscious and practical.

That this is true is shown, among other ways, by the fact that so few amateur players have any definite idea of what we mean by a key, when we use the word in the sense of a group of tones having a definite relation to each other. In fact, a piano player need not care in what key he is playing. He need only observe the signature, and put his fingers on the sharp or flat keys provided by his instrument. It makes no difference, for example, in what key a piece of music is written; any given note, say

is either G, G♯, or G♭, that is to say, a certain invariable white key on the piano, or one of the adjacent black keys. The signs × and ♭♭, which move the note up or down a whole tone, are comparatively rare.

The only mental exertion the player is *obliged* to make, is to remember which note-signs are sharped or flatted by the signature, and to find the proper piano keys when he sees a ♮, ♯, or ♭♭.

To resume, then, if you give a pianist a new piece of music to play, he looks at the signature, impresses on his mind what notes are sharps or flats, and then he puts his fingers on the keys indicated by the dots on the different lines and spaces. The difference between a tyro and a master with respect to reading at sight is only in the rapidity with which each is able to perform this simple process.

WHY A SINGER CANNOT READ NOTES LIKE A PLAYER.

Now, can a singer proceed in the same way? Can he treat his voice like an instrument? Unfortunately, he has no keyboard in his throat; neither are there any stops or ready-made notes. How then is he to sing the passage we started out with? Well, he can play it on the piano and imitate the sounds with his voice a sufficient number of times until he knows the passage by heart. That is one way, and, I may add, that is the way in which most people sing. But, when he has learned this piece by heart, that does not give him the ability to sing the next one without going through the same process.

He must learn that by heart too. He does not acquire any power or independence of an instrument. Yet this is the way in which our church choirs, oratorio societies, yes, opera singers, learn their parts. It is true that in time it becomes easier for such singers to learn a new piece. It takes them less time. But still they have to learn them by heart. They seldom reach the point where they can take up a new piece and sing it off, without first going to the piano and playing it over.

But cannot I convert my voice into an instrument by learning the notes themselves by heart, so that I can sing A when I see A, and sing A♭ when I see A♭? What would such a task involve?

Let us say that the compass of my voice is two octaves. This comprises 25 semitones. Is it possible for me to learn these 25 tones so well that I can sound the pitch of each as readily as I can pronounce any one of the 25 letters of the alphabet, no matter in what order or sequence they are presented? I do not think many people can do that. I believe no one tries to teach vocal music in that way.

Well, if I cannot do this, I cannot convert my voice into a keyboard that can be played upon like a piano, and I cannot read notes as a piano player reads them.

HOW SOME PEOPLE READ MUSIC.

I have taken some pains to find out how people *do* read music; and although I have been favored by an extensive acquaintance with musical people, I have never met any one who really did it unless it was by Tonic Sol-fa principles. I do not mean that all such persons were taught by the Tonic Sol-fa method, for many good teachers follow these principles to some extent, without knowing how beautifully they have been worked out into a system of instruction. Now listen to some typical cases in which singers persuaded themselves into the belief that they were reading music.

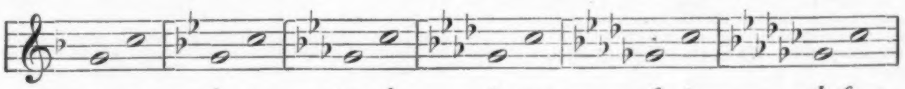
The result of closely questioning a prominent lady-member of a notable singing society was that she had naturally an extremely fine ear, and if any instrument in the accompanying orchestra or if any of the singers near her struck her note, she would pick it up instantaneously. She knew in some mysterious way what the right note was that would fit into each place. Now, it is obvious that this sort of thing is not singing by note. A chorus composed of members all working by this method would make some very significant pauses if required to sing a piece they had never seen or heard before.

My second case is that of a member of another excellent singing society. She explained to me that she observed how many steps the notes were apart on the staff, and that her experience guided her in rising and falling to the right pitch as her eyes followed the notes. Let us investigate this

* Read at the fourth annual meeting of the American Tonic Sol-fa Association in Philadelphia.

case. It has two factors: the spaces of the staff and experience. Let us take a simple case:

s d' d f f t t, m m l l, r r s



r s l, r m l t, m f t d f

From the standpoint of the tonic sol-faist we have here no less than seven different mental effects produced by the two notes in the thirteen keys; but it would not be fair to judge the interval method from our standpoint, and to ask the lady what mental effect she is aiming at when she sings the intervals from G to C, G to C♯, G♯ to C♯, G♭ to C, and G♭ to C♭. She does not care. All she is trying to do is to sing through an interval of six or seven semitones, counting in the first and the last note each time. Indeed, at first sight this seems to be much simpler than our way. No matter on what lines or spaces any two notes on the staff may be, they represent only two intervals composed of an odd or an even number of semitones.

This is true, as has just been illustrated, for all the signatures; consequently, a change of key in the course of a piece or an accidental ♭ or ♯ only widens or narrows the interval to the amount of one semitone. All this looks a great deal easier than Tonic Sol-fa, until we come to study what it involves. Instead of speaking of so many semitones compressed in an interval, the instruction books call the intervals augmented and diminished fifths, fourths, thirds, etc.; but I think I can put the case more clearly in the former way.

By this method then you must learn when any note is given to strike any other note either above it or below it at a distance of 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, or perhaps more semitones. Perhaps some people can do that. However, when you have accomplished this task, you can sing, but you cannot sing by note until you have trained your eye in reading the staff to such a point that you can instantly recognize how many semitones apart any two consecutive notes are.

I do not know how much practice that requires, as I have never tried it—and I never shall try it. Indeed, if the music books and the singing masters of the old school would come forward honestly and make a clean breast of what they expect their pupils to accomplish, the great mass of mankind would shrink back in dismay and leave our ennobling art to the few gifted ones who can sing without having to learn crotchets and quavers, flats and sharps.

The second factor in the case of the lady whose method we are examining, is the experience that guided her in striking the right pitch as her eyes followed the notes. This experience probably means the amount to which her ear has been benefited by her previous singing, so that it quickly supplies the needed note when a chord is struck. This it would do, even if the singer did not look at her notes, and consequently it has nothing to do with reading music.

The third and last case to which I will call your attention is that of a distinguished operatic artist, who has retired from the stage. She avers that in all her operatic experience in both hemispheres, she never knew an artist who could sing by note in the sense stated above. They all learned their parts by heart by dint of hard labor and constant testing by means of the piano.

Those who had the best musical memory had the easiest time of it. She argued that no one cared how a singer learnt his music, provided he executed it well when he came before the public. I suspect, however, that the singer himself cared. These artists, then, are dependent on the piano, and cannot practice unless they happen to be where there is one, while we can put our music in our pocket and learn it, if we chose, while taking a stroll. This lady did not believe that reading music in the way I described could be done.

Can it be done? You all agree with me that it can. But how shall we explain the process to our uninitiated friends? How shall we tell them what goes on in our minds when we sing music at sight?

THE TONIC SOL-FA PROCESS OF READING NOTES.

We do not remember the pitch of each of 25 semitones. We do not puzzle out the interval between two consecutive notes on the staff. We need not remember any pitch unless we choose. Seven tones are all we need to know. Any given key contains only seven notes, and the keys are all alike to the voice.

But is it possible to learn seven tones so well that we can strike any one of them with perfect certainty whenever we please? Undoubtedly; and for scientific reasons.

THE SCIENTIFIC BASIS OF THE TONIC SOL-FA METHOD.

In these days of popular science, everybody may be presumed to know the following well established seven propositions:

1. All music is due to regular vibrations.
2. The more rapid the vibrations, the higher the pitch.
3. A short stretched string vibrates faster than a long one.
4. If a string 15 inches long produces a certain note, half the length of this string will produce a note having a very great resemblance to the first, but higher in pitch because it makes twice as many vibrations per second. We call it the octave.
5. If we take 10 inches of the same string, we obtain another note making $1\frac{1}{2}$ times as many vibrations as the first; and with 12 inches of the string we get a note making $1\frac{1}{4}$ times as many.
6. Now if we tune four separate strings to these 4 notes and sound them together, we obtain the most perfect harmony possible. The same is true if we start with any other length of string than 15, provided we observe the same proportion.
7. The numbers expressing the vibrations of these notes, 1, $1\frac{1}{4}$, $1\frac{1}{2}$, and 2, are in the simple ratio of 4, 5, 6, and 8.

Our minds are so constituted that they take pleasure in simple numerical relations, and the inner ear is provided with a beautiful organ, called the rods of Corti, which readily responds to sounds having such relations. We are not conscious of these when we hear the sounds, but any tone having a definite numerical relation to one heard just before, produces a distinct mental effect upon us.

There is another reason why this should be so.

Every tone of a musical instrument or of the voice is composed of a principal or fundamental note and of a number of other fainter notes called overtones. Some of these overtones have the same number of vibrations as some of the overtones of other tones of the scale. In other words, each note of the scale has some constituents in common with other notes. If we call a note making say 400 vibrations *doh*, one making 500 *me*, and one making 600 *soh*, their overtones, which in each case make 2, 3, 4, 5, etc. times as many vibrations, will compare as follows:

	1	2	3	4	5	6
doh..........	400	800	1200	1600	2000	2400
me..........	500	1000	1500	2000	2500	3000
soh..........	600	1200	1800	2400	3000	3600

Here we see that the 5th overtone of *doh* is the same as the 4th of *me*; the 3d overtone of *doh* is the same as the 2d of *soh*; the 6th of *doh* is the same as the 5th of *soh*; and the 6th of *me* is the same as the 5th of *soh*.

Similar coincidences can be shown for the rest of the scale. *Every note repeats a portion of the tonic or keynote, doh.* Hence, when the keynote has been struck, any other note conveys to our ears a portion of what we heard before, but in combination with something new. We do not know all this when it takes place; but it all contributes to make the different notes of a key sound natural. It makes them seem sa though they belonged together and formed an exclusive group or family of sounds, all having a family likeness, but each possessing an individuality of its own, by reason of which it produces its own peculiar effect upon the mind of the singer and of the hearer.

Now, it is the chief merit of the Tonic Sol-fa system, that it has made these mental effects the basis of musical instruction without troubling the learner with the theory. Besides the three notes mentioned above, namely, *doh*, *me*, *soh*, with vibrations in the ratio of 4, 5, 6, and the octave *doh'* (one *doh*), 8, there are four intermediate notes whose vibrations also bear simple ratios to those of *doh*. Each of them produces a distinct effect upon the mind. Thus we get the natural scale:

doh, ray, me, fah, soh, lah, te, doh'.

It does not matter whether we take a *doh* of 400 or any other number of vibrations, provided we preserve the ratio of the other notes; or to put at differently, it does not matter what pitch we start with.

Well, some one may reply, "That sounds very much like refurbishing an old story and making many words about our old friends, do, re, mi, etc., invented 680 years ago by Guido of Arezzo—a system which every one uses who learns to sing."

Let us contrast the Tonic Sol-fa with the ordinary method, and see if this is so.

Most people in this country, like the lady in the second case referred to a short time ago, are taught to sing *intervals* They are drilled to sing the second, third, fourth, fifth, etc., above or below any given note, and they use do, re, mi, etc., merely as convenient syllables to sing, since they are more vocal than the latter names of the notes or the numerals. Some attempt to associate *do* with the pitch of C, *re* with the pitch of D, etc.

Our use of these syllables is very, very different.

THE DOCTRINE OF MENTAL EFFECTS.

To us *soh* means *scientifically* a note making $1\frac{1}{2}$ times as many vibrations as any given key-note, which we always call *doh*; and *practically* it is the name of a sound producing so specific an effect upon our minds that we can pick out this note whenever it occurs in a piece of music we are listening to, and so definite that we can strike it with the voice as soon as we know the keynote. What that effect upon the mind is, cannot be easily described in words. It may suggest one thing to one person and another thing to another person, and yet we are warranted in calling it a definite effect. At any rate is an effect *distinct* from that produced by any other note of the key. Let me illustrate how this is possible by quoting a passage which I translated from the great physicist Helmholtz in reference to a kindred subject.

"When different listeners attempt to describe the effect of a piece of instrumental music upon them, they are often greatly at variance as to the situations or feelings which they suppose the music to convey. Those ignorant of the subject may thus be led to ridicule such enthusiasts, and yet these may all be more or less correct, because music does not portray feelings and situations, but only moods or states of mind, which the hearer cannot describe in any other way than by reference to external circumstances under which the same moods are usually produced in him. But, then, different emotions, under different circumstances may give rise to the same moods in different individuals, and conversely the same emotion may produce different moods. Love is an emotion. As such, it cannot be directly represented by means of music. The moods of a lover may be extremely varied. Music may express, for example, a dreamy longing after transcendent bliss, which might be caused by love. But exactly the same mood might arise from religious excitement. If therefore a piece of music expresses such a mood, it is not paradoxical that one listener should find in it the *yearnings* of love and another a pious longing for a better world." *

Similarly, the note *soh* may suggest different thoughts in different observers, but there is not the slightest danger that its effect, will be confounded with that of other tones.

No one has mastered this note until he is conscious of its peculiar effect. The Tonic Sol-fa system drills its scholars on this effect, and does not graduate them until they feel it.

Do you doubt the existence of such an effect? Your doubt is contradicted not only by the inherent scientific probability of its existence, which I have attempted to show, but by the experience of hundreds of thousands who feel it. Even if it were all imaginary with them, it would be very probable that your imagination would become similarly affected by the same course of study—and then you could do what they can.

Our claim then is that each note of the scale has its own peculiar mental effect independently of the pitch. When you have mastered each note in this way, you are beginning to be a musician. Your ear is cultivated. Your voice responds to the demands of your brain and of your ear, and it now becomes a matter of comparative ease for you to sing from any notation, even though it be as confusing as the staff or the cuneiform inscriptions.

The reader of vocal music, then, does not care in the least whether he is singing C, D, E flat, F sharp, etc. He gets his proper pitch at the beginning of the piece, and the rest is all *doh*, *ray*, *me*, etc., to him. Musicians that have not made a special study of singing do not find out this vital difference; but then that does not prevent many of them from posing as authorities in matters of vocal music, nor from being very indignant when it is politely hinted that they do not know what they are talking about. People of this kind invariably condemn the Tonic Sol-fa method without a hearing.

READING VOCAL MUSIC.

We are now ready to understand all that is required to read music by the Tonic Sol-fa method. It necessitates:

1. Having in the mind the seven tones *doh*, *ray*, *me*, etc., as distinct as the seven colors of the rainbow are to the eye.
2. Understanding the signs by which they are denoted upon paper beginning with the Sol-fa initials, and ending with the staff crochets, quavers and other umpleasantnesses.
3. Being able to join any given words to the tones.

THE NOTATION.

It is not the purpose of this essay to give an outline of the Tonic Sol-fa method with its admirable devices for teaching time, tune, harmony, voice culture, and the rest; but I cannot fully illustrate my subject without discussing the notation. To the uninitiated a page of Tonic Sol-fa music looks as unintelligible as shorthand, and they very naturally conclude that there is no use in taking the trouble to learn all that, because they would have to learn what they call "real music" afterward anyhow. So why not learn it in the first place? The use of the Tonic Sol-fa notation is two-fold—in teaching the tones and in facilitating the reading of difficult music.

THE TONIC SOL-FA NOTATION FOR BEGINNERS.

Having shown that the ear recognizes the relationship of tones, it is only necessary to indicate this relationship in order to make the learner sing the required tone.

Now, the simplest conceivable way of indicating this relationship is by using the initials of the syllables with which the learner is to be taught to associate it. If you give him a certain pitch for *doh*, and tell him to sing what you write on the blackboard, he will know that he has to strike *soh* the very instant he sees an *s*, and *me* the very instant he sees an *m*. Nothing has to be explained. These initials explain themselves. Not so, with the staff. There you have to explain the signatures and give rules for the location of *doh*. The response of the learner cannot be instantaneous. He has to go through a course of reasoning before he knows what he is required to sing when you make a dot on some line or space. And worse than this. You have to change the pitch of *doh* constantly, so as to make sure that the learner acquires the power to strike *soh* and *me* in different keys. Now, the moment you change the pitch, you change the staff signature and the location of *doh*. Hence the learner has to go through another course of reasoning before he knows what you want him to do. How much more simple is the new way! Here there is only one way of writing *doh*, *ray*, *me*, etc., no matter what the pitch may be. Can any one doubt which way is easier for a beginner who knows nothing of music?

Let us illustrate further by describing what goes on in the mind on singing the first three notes of the "Old Hundredth" from the staff and from the Tonic Sol-fa notation= singing in both cases according to true Sol-fa principles.

Praise God from whom all blessings flow.

KEY G.

: d | d : t, | l, : s, | d : r | m

Praise God from whom all blessings flow.

THE FIRST AND SECOND NOTES.

When you see one sharp in the signature, you must know that the piece is in the key of G. Find this pitch. The first black dot is G; therefore it is *doh*. To this tone you must sing "Praise God."

Find the pitch of G. The d means you must think *doh* with this pitch and sing to it the words "Praise God."

THE THIRD NOTE.

The third note is one step below *doh*; therefore it is *te*, Think the tone *te*, and sing to it the word "from."

Think the tone *te*, and sing "from."

If there had been an accidental sign, a sharp, a flat, or a natural, before one of the dots in the staff, there would have been yet more to think about before you would have known what tone to sing; while in the Tonic Sol-fa notation you would still have had only an initial letter, which would have told you directly. That this preliminary reasoning is a great obstacle imposed upon the singer by the staff notation will be more fully realized when it is remembered that the music moves on at a uniform speed, and that those who stop to reason are left behind.

THE TONIC SOL-FA NOTATION FOR DIFFERENT MUSIC.

So much for teaching beginners and for simple music. Let us see if those are right who say: "Oh, yes, it does very well for children and plain chanting, but it is unsuited to the complicated works of modern composers."

One evening when I was studying the merits of the system, I had the curiosity to know how much labor it would take to figure out a piece of difficult music; just to see what kind of thinking singers would have to go through with, I selected for this purpose Schubert's "Erlkönig," which, I suppose, bears about the same relation to an ordinary ballad or to a hymn tune as Macaulay's essays bear to a nursery

* Helmholtz. Die Lehre v. d. Tonempfindungen, p. 369.

tale. It passes through at least twelve changes of key in all. I translated it into the Tonic Sol-fa notation, and the length of time it took encourages me in the belief that not many people could sing that piece from the staff without the help of an instrument, if they had not seen or heard it before. Any tonic solfa-ist, however, that holds an intermediate certificate, would experience little difficulty in singing the translation at sight under the same conditions.

It follows then that the Tonic Sol-fa notation and system are adapted to music of a high character—indeed, we know that music of the highest character is published in this form.

PHILANTHROPIC ASPECT OF THE SYSTEM.

But there is another aspect of the system that I value more highly. It is that Tonic Sol-fa is especially efficacious in developing a correct ear in those who are not naturally musical. In other words, it is calculated to be a powerful agency in rendering music accessible to the masses of mankind. Music would be a great civilizer if it could reach the masses; that is to say, if they could become performers and not merely listeners. Tonic Sol-fa brings it within their reach, and adds to it the charm of success.

It is mainly for this reason that I have been willing to leave other duties and to lift up my voice in favor of this system; because I know that it is able to raise the masses to a higher level of life in the course of one generation. It is able to make us a better people.

"RED SKY"—ADDENDA.

IN the article with the above title, in the SCIENTIFIC AMERICAN SUPPLEMENT, April 19, 1884, by some inadvertence the word "meteoric" dust was used synonymous for *volcanic* dust, yet although the word was wrong, there was nothing to mislead in the sense, and it must have been plain to the intelligent reader that the volcanic dust from Java was spoken of and intended.

Because of the absence of a visible meteoric display, suitable to produce such an effect, "meteoric dust" proper was not then considered; besides, personally coming in contact mostly with the support of the Java dust idea, *that* seemed by far the greater objection to combat. Since the publication of the article I have received a number of letters expressing different views in regard to it; among them were some remarks quite severe and antagonistic in tone. The burden of criticism, from a gentleman unfavorable to the ideas expressed in this article, was to the effect that the evidence of the *spectroscope* was the all-convincing argument in the case, and that that strongly opposed the argument of the article. I do not, however, agree with him in his spectroscope evidence, either as to "meteoric" or "volcanic" dust. The volcanic dust would be too low; the meteoric dust, according to conditions, as will be seen, would be too high or too unfavorable.

If the meteors were near at hand, we would have seen them. In order to have formed sufficient dust to have produced such an effect on the sky, there should have been such a display of meteors as the world never saw before, and the dust would have rained down so plentifully as to have left no doubt of its presence; it could have been scooped up by the handful, and would have made the sky resemble the atmosphere over a Pittsburg. The storm centers would have quickly gathered it in their vast centers. It would have been of short duration, and not have continued for months.

But it may be said that it came from distant meteors—that the earth, as it were, passed through a sea of meteoric dust, which was produced by meteors within the path or orbit of the earth. Even in this case the effect could not have been so continuous, and would not have lasted for months, and only been visible under certain conditions of the atmosphere; and then in this case, if it had come near enough to the earth to have been collected, it would have come under the influence of the scores of storm centers which encircle the earth, and been concentrated and precipitated in quantities by the rainfall. And if too far away, have been collected, and simply visible, its visibility would not have been confined to certain hours; and from its distance its relation to the earth would not have been such as to have been visible only when the sun was below the horizon; our relation to it and the sun would not have been such as to produce the red sky results, for what produces this result, or phenomenon, is something within the upper cloud region—by the light from the sun shining through and up under it—as it were, illuminating the vault of the great dome under which we live.

To undertake to explain such a phenomenon without taking into consideration the teachings of the weather map is most absurd.

There is nothing uncertain about this wonderful map. It is like a photograph. What is on the face of nature is reproduced, and what is not there cannot be manufactured, even to suit the erroneous conceptions of the wisest of the earth.

In regard to the volcanic dust from Java, it was only claimed that the explosion threw the dust 3,000 feet high. It would have been necessary for it to ascend over 23,000 feet in order to have got above the influence of the areas of(!) low barometer. At only 3,000 feet such dust would, in a few days, have been precipitated by the numerous storm centers it would have come in contact with, for the weather map shows us that these storm centers must be well distributed over the earth, and that they travel in belts, and are from three to five days apart, whereby the chances of such movements of dust are very much complicated. My opponent objects to the evidence of the weather map. I object, for reasons herein mentioned, to the supposed evidence of the spectroscope. I will not say that dust has not been gathered or seen in the atmosphere, for undoubtedly there is more or less dust in the atmosphere at all times; but, as I think is herein conclusively shown, such dust could not possibly be the cause of the beautiful and delicate redness of our sky. Distant meteors would have been too far away; near ones, or the volcanic dust from Java could not, from the peculiar condition and formation of the atmosphere, have traveled far, and could no more have traveled to the United States than the water from the Pacific Ocean could cross the land, up hill and down hill, and empty into the Atlantic.

Wind is the only motive power known to the face of nature whereby the atmosphere is moved from place to place, and the wind depends upon the storm centers which we term "low," and dust, from its very nature, could not possibly pass the barriers which they present; for at their center the wind is blowing at the same time from all points of the compass; so between this and the rainfall, the dust would find a passage more difficult than those who knew not of the revelations of the map would suppose.

My critic objects to my objecting to the astronomers being recognized as authority in the matter. I said in substance in former article that it was a meteorological question, and I here repeat the same.

And he says it is an optical phenomenon. In a broad sense it is *optical;* but no more or less so than the delicate suspended moisture that causes the red sky effect. As shown in former article, this, in its fullest sense, is nothing but clouds, for moisture present in the air, even so diffused and fine as not to be visible when seen at right angles to the sunlight, is as much a cloud formation as the "nimbus" clouds from whence comes the heavy rainfall.

The meteorology of the present, not the absurd meteorology of the past, as taught in the regular physical geographies before we knew anything to speak of about the subject—the meteorology of the present reveals to us a most plausible and satisfactory explanation, as given in former article (April 19). Why not accept this? Why go to something foreign and impractical?

Dust, at the most, can only reflect light, and it would have to be very bright and crystal-like to do that. It has no power, like the suspended drop of water, to refract the light of the sun. It has no power of suspension, and only by the merest accident, by powerful upward currents, can it be kept suspended in the air. It is heavier than normal air, and only by air that is condensed by pressure upward—by upward currents—can it be supported at any height in the atmosphere, while water when acted on by heat, to which it is very susceptible, has the balloon power of suspension, and but for the action of the wind, produced by "low," whereby it is compressed and its weight to the square inch greatly increased, does it return to the earth as rain, and even then some of it, that which is unaffected by the lateral pressure of the wind, remains suspended still. But, it may be asked if dust might not be carried upward at the center of "low," where the current is heavenward. What little is already within a "low" center might be, but not that which was from any great distance, for what was from a distance would have been precipitated by the rainfall of "low" (low barometer) before it could have reached the center, unless perhaps in the case of a tornado which would be very *local* in its effect. Then, provided it reached the upper currents at "low," above this point in the heavens, the movement of the atmosphere is then toward "high," and downward.

At the surface of the earth, and upward, we know not exactly how high, but for four miles or more, the movement is from the "high" to the "low;" above, the direction is reversed—from the "low" to the "high." On the surface the supply of air is from the bottom of the column "high;" above, the top of this column is being replenished by the atmosphere from "low;" otherwise "high," from the constant drain, would become exhausted. So at "low" the motion is inward and upward; at "high" it is outward and downward.

Now in the light of such evidence as this—evidence that could only have been obtained from the weather map, and which the weather map makes so plain—why seek an explanation so foreign to that which is most reasonable? The reason is plain. The weather map came so quietly into the world that few regard it with interest. It was established in 1870. In 1883 prominent institutions in the land had not had it, and the few who may have had it have apparently not given it much close attention. They have regarded it as a novelty and curiosity, but not as an expounder of the grand physical laws under which we live. The men who should have taken deep interest in this map have all these years neglected it. They think me ignorant for not accepting their explanation of the red sky. It is not pleasant to oppose such authority, yet here is the evidence, and by it we must be guided.

I think if these men had studied this wonderful map that they would to-day know far more about the beautiful system whereby nature provides the sunshine, the rains, the dews, the fogs, the beautiful and majestic changes of the clouds, the temperature, the heat and the cold, and all the varieties and conditions of atmosphere under which we live. For the weather map our praises cannot be too great. It has solved many a problem which the old physical geography left unsolved, and of which without the map we must have forever remained in ignorance. Well may it be said of this map, "The dew of thy birth is the womb of the morning." Before its advent in the department of meteorology we were in utter darkness; now through its grand revelations we are brought face to face with phenomena heretofore enshrouded in mystery. From the very nature of things—from undeveloped conditions—our ancient brethren were not able to understand these phenomena. The advancements of the age have permitted us to understand things far more valuable than the ancient riddle of the sphinx.

May this discussion result in realizing the former darkness and in revealing the light so accessible to us if we will but place ourselves into position to obtain it.

ISAAC P. NOYES.

Washington, D. C., May, 1884.

CONTRIBUTIONS TO AZOTOMETRY.

By CARL MOHR.

AMONG the many methods proposed for determining nitrogen in nitrates and manurial mixtures, none has met with so much approval as the reduction process with ferrous chloride, and measurement of the nitric oxide gas, as recommended by Schlosing, Grandeau, and others. Schlosing collects the gas over mercury, and Grandeau over water. To prevent the liquid from reascending into the decomposition flask, Muntz passes a current of carbonic acid through the apparatus and absorbs it by the introduction of a small volume of strong soda-lye. This ingenious proposal greatly facilitates the operation, since the nitric acid gas is evolved only very slowly from the ferrous solution, a prolonged gentle boiling of the liquid being required. Here the carbonic acid renders essential service, and enables with ordinary care the operation to be completed without accident. This method has, however, one defect; the inside of the gas burette moistened with soda-lye becomes very soon incrusted with crystals of sodium carbonate, rendering it difficult or impossible to read off the volume of gas. The author therefore employs instead of mercury or water a soda-lye of specific gravity 1·2 to 1·25. A lye of this strength absorbs the carbonic acid completely, and does not deposit crystals of sodium carbonate upon the glass. The current of carbonic acid passing through the apparatus disappears more and more toward the end of the process by absorption, and finally the volume of gas remains constant.

The manipulation of a gas burette with caustic soda is rather difficult. The author has therefore designed a burette with a glass tap and a small cylindrical funnel. The burette is filled by aspirating from above by means of a caoutchouc tube, and the tap is then closed.

The author has also designed an azotometer for ammoniacal salts and their mixtures. If the salt to be examined is approximately pure, a two per cent. solution is prepared. Of manurial mixtures 5 or 10 grms. are taken to 100 c. c. A graduated pipette, holding 10 c. c. and fitted with a small glass tap and an efflux point, is filled with this solution. A decomposition flask holding 150 c. c. is charged with 50 c. c. of a solution of bromine in caustic soda; the flask is then closed with a caoutchouc stopper having two perforations, through one of which is inserted the above mentioned pipette, while a gas tube serving as outlet passes through the other. The latter is connected by means of a short caoutchouc tube with the gas burette above described. The introduction of the caoutchouc tube is necessary, as, after the decomposition, the flask must be shaken in order to liberate the absorbed nitrogen. After fitting up the gas burette and introducing the pipette the tap is opened cautiously, and 10 c. c. are allowed to flow in drop by drop. The evolution of gas takes place quietly and without perceptible heat. After the 10 c. c. have thus run in, the apparatus is well shaken.—*Zeitschrift Anal. Chemie.*

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